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EDITED BY

HENRY WOODWARD, LL.D., F.R.S., F.G.S., F.Z.S., F.R.M.S.,

OF THE BRITISH MUSEUM OF NATURAL HISTORY;

PRESIDENT OF THE PALÆONTOGRAPHICAL SOCIETY,

AND VICE-PRESIDENT OF THE MALACOLOGICAL SOCIETY;

MEMBER OF THE LYCEUM OF NATURAL HISTORY, NEW YORK; AND OF THE AMERICAN PHILOSOPHICAL SOCIETY, PHILADELPHIA; HONORARY MEMBER OF THE YORKSHIRE PHILOSOPHICAL SOCIETY; OF THE GEOLOGISTS' ASSOCIATION, LONDON; OF THE INSTITUTION OF MINING AND METALLURGY, LONDON; OF THE GEOLOGICAL SOCIETIES OF EDINBURGH, GLASGOW, HALIFAX, LIVERPOOL, AND SOUTH AFRICA; CORRESPONDING MEMBER OF THE GEOLOGICAL SOCIETY OF BELGIUM; OF THE IMPERIAL SOCIETY OF NATURAL HISTORY OF MOSCOW; OF THE NATURAL HISTORY SOCIETY OF MONTREAL; AND OF THE MALACOLOGICAL SOCIETY OF BELGIUM.

ASSISTED BY

ROBERT ETHERIDGE, F.R.S. L. & E., F.G.S., F.C.S., &c.

WILFRID H. HUDLESTON, M.A., F.R.S., F.G.S., F.L.S., F.C.S.

GEORGE J. HINDE, PH.D., F.R.S., F.G.S., &c.

AND

HORACE BOLINGBROKE WOODWARD, F.R.S., F.G.S., &c.

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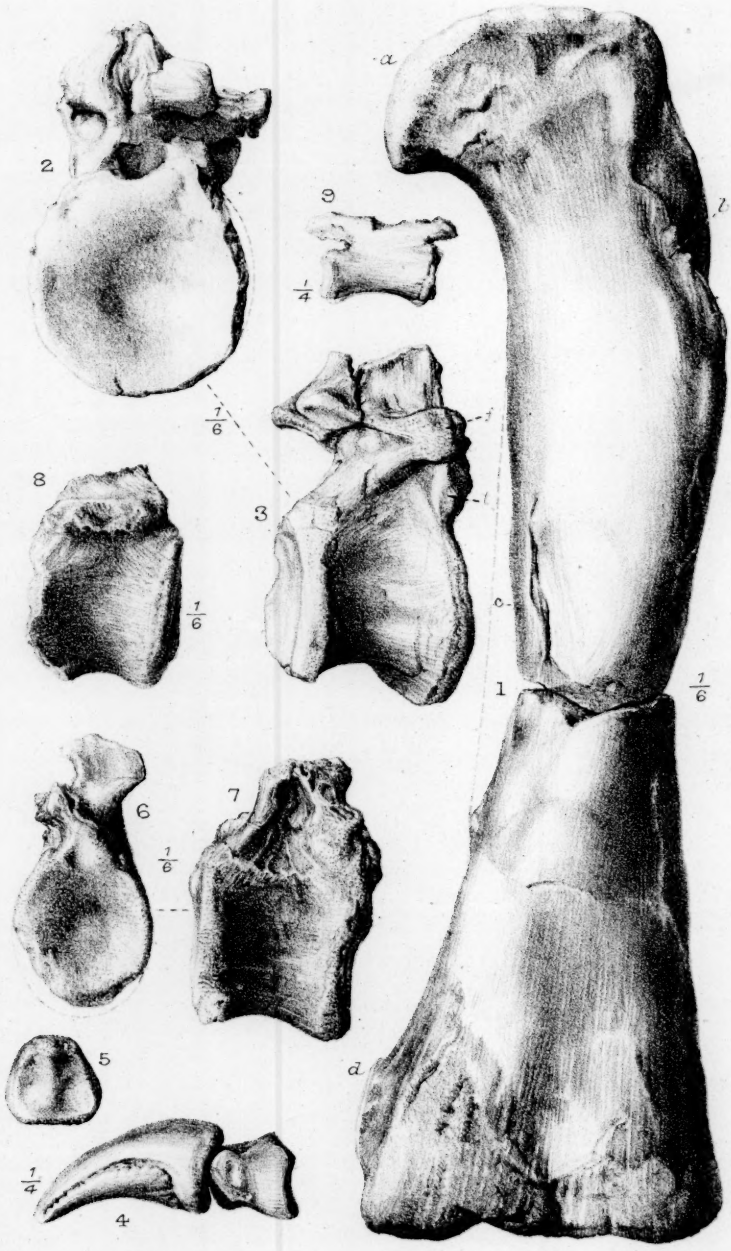


G. M. Woodward del. et lith. West, Newman imp.

Figs. 1-5, Avalonia Sanfordi. (Seeley.) Figs. 6-9, Picrodon Herveyi. (Seeley.)

Rhætic Beds, Wedmore Hill.

THE

GEOLOGICAL MAGAZINE.

NEW SERIES. DECADE IV. VOL. V.

No. I.—JANUARY, 1898.

ORIGINAL ARTICLES.

I.—On large Terrestrial Saurians from the Rhætic Beds of Wedmore Hill, described as *Avalonia Sanfordi* and *Pickodon Herveyi*.

By H. G. Seeley, F.R.S., Professor of Geology in King's College, London.

(PLATE I.)

In 1894 Mr. W. A. Sanford described, in the Proceedings of the Somerset Archæological Society (vol. xl, 1894, p. 234), the geological circumstances of the discovery of a large fossil reptile. The fossil bones were found by the Rev. Sydenham H. A. Hervey and himself in the Rhætic beds in the parish of Wedmore, in the Vale of Glastonbury; and compared to *Megalosaurus* in its large size and carnivorous character. The remains were generously presented to the British Museum (Natural History) at South Kensington. I have now to redeem a promise made by Mr. Sanford in his paper that I would name and describe the specimens.

The fossils comprise teeth, bones of the hind limb, dorsal and caudal vertebræ, and ribs. The discoverer remarks upon the way in which the bones appear to have been broken, crushed out of form, and scattered in the deposit. These results are partly due to transport of the specimens at the time of deposition; and partly, apparently, to movements of the strata associated with the uplifting of the rocks in that part of England.

Only two teeth were saved; they indicate two distinct genera. One tooth (p. 2, Fig. 1) is of a generalized Megalosaurian type, and has the summit of the crown greatly worn with use, and rounded. The crown is broad and thick, 12 mm. wide and 7 mm. in thickness; but towards the base of the crown, the width from front to back increases faster than its thickness. The anterior margin is rounded from side to side, as well as convex from above downward. If any serrations were ever developed, they were in the proximal part, which is worn away. In type the tooth resembles *Zanclodon* and *Euskelesaurus*. Those types agree with *Megalosaurus* in the limitation of the anterior serrations to the upper margin of the tooth in the lower jaw. Mr. Sanford states that the root of the tooth crumbled, and that portions of the lower jaw were found. Taken by itself the

crown suggests affinity rather with *Zanclodon* than *Megalosaurus*. The serrations on the hinder border are at right angles to the margin. I refer this tooth to *Avalonia*, the fossil being found in Avalon, the district associated with King Arthur and his Knights of the Round Table.

Fig. 1. Fig. 2.

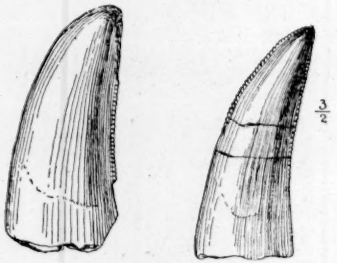


Fig. 1.—Tooth of *Avalonia Sanfordi*, Seeley.
Fig. 2.—Tooth of *Picrodon Herveyi*, Seeley.
Rhætic Beds: Wedmore (Vale of Glastonbury).

The second tooth (Fig. 2) is also represented by an imperfect crown. It is from the lower jaw, but of a very different type. It is $\frac{4}{5}$ inch long and $\frac{3}{10}$ inch wide at the base. It is sharp-pointed and slender, and the only tooth which at all resembles it in form is one from the collection of the late Rev. P. B. Brodie, found near Warwick, now in the British Museum (Natural History), which I refer to the same genus. This acuminate tooth, manifestly smaller than the tooth of *Avalonia*, and imperfectly preserved, is flattened externally and rather convex on the inner side, where there are three or four short slight ribs towards the lower half of the crown, which somewhat recall the ribs in the teeth of *Suchosaurus*, which the type resembles in form; but the crown differs from that genus in being more pointed, and especially in having the anterior and posterior margins serrated. The anterior serrations are limited to the summit of the crown. Their general direction is at right angles to the curved surface, but they have a perceptibly greater upward tendency. The posterior serrations are also directed upward. This constitutes a distinct resemblance to *Thecodontosaurus* and a difference from *Megalosaurus*, in which the serrations are at right angles to the cutting margins of the tooth, as they are in the short crown of *Palæosaurus*. The nearest approximation to this kind of serration is made perhaps by the French genus *Dimodosaurus*. But the serrations, except for their direction, are similar to those of *Megalosaurus*, and there is no median ridge running down the length of the tooth such as is figured by M. Gaudry. The tooth indicates the genus *Picrodon*. I have therefore no doubt that the remains of the skeleton preserved belong to two distinct though closely allied animals, of which the second was the smaller.

The true nature of the larger animal, *Avalonia Sanfordi*, is indicated by the remains of the femur and other parts of the hind limb. The

femur (Pl. I, Fig. 1) is about 38 inches long. It is a moderately strong bone, compressed from front to back, with the proximal and distal ends in the same plane. There is no trace of a sigmoid curve such as is seen in *Palæosaurus*, and to some extent in *Megalosaurus* and *Dimodosaurus*. The least transverse width of the proximal end is $9\frac{1}{2}$ inches and the greatest width $10\frac{1}{2}$ inches. Of this width, at least $2\frac{1}{3}$ inches is due to the inward direction of the convex articular surface, which measures 6 inches from front to back in the middle of the articulation, is flattened above, and is round from above downward as it extends inward. Below the proximal articulation towards the outer border, the front of the bone is impressed for a width of about 3 inches. This condition somewhat approximates to that seen in the corresponding part of the femur of *Euskelesaurus Browni*; only in that type the transverse expansion of the head of the bone is much less, and the shaft of the bone is nearly cylindrical, shorter, and relatively stouter. The lower border of this impression is an oblique ridge, which passes downward and outward, but is not appreciably elevated; it is 4 or 5 inches long, and is the only representative of the proximal trochanter of *Megalosaurus*, which is scarcely developed in *Euskelesaurus* and *Palæosaurus*, is almost lost in *Massospondylus* and *Dimodosaurus*, and passes away in some Zanclodonts. This is one of the most distinctive characters of the bone. Below the termination of the ridge the external lateral contour of the bone is concave in length, and this causes the shaft to narrow from a width of 7 inches to $5\frac{1}{2}$ inches in its middle length, below which it widens again to $11\frac{1}{2}$ inches towards the distal end. The middle length of the inner lateral border is occupied by a trochanter, which is now broken away but had the backward direction seen in carnivorous genera of Saurischia. Its broken base is a foot long, is perfectly straight, and occupies the middle third of the length of the bone. Above the trochanter the concave inner border is approximately parallel to the convex external border. The widening of the distal end of the bone is similarly due to an inward extension of the bone below the trochanter in a concave contour. This inner side is flattened and inclines slightly forward, being supported by the large inner distal condyle. The length and position of the lateral trochanter are distinctive; in *Euskelesaurus* it occupies the middle of the bone, and in *Massospondylus* it is towards the middle, but in both the African genera it is relatively shorter, while in *Palæosaurus* and *Megalosaurus* the proximal position of the trochanter is as pronounced as in *Zanclodon*; so that this also is a distinctive feature of the bone.

The distal end is about $11\frac{1}{2}$ inches wide. In front there is a slight concave longitudinal channel, slightly external to the middle width. The distal extremity is truncated. The larger inner condyle seen behind is 7 inches from front to back, and separated from the outer condyle by a moderately deep concave channel about 2 inches wide. The back-to-front measurement between the two channels exceeds 4 inches. The outer posterior surface external to the lesser condyle is oblique, and has the usual compressed aspect.

The bone is manifestly that of a new Zanclodont Saurian, and the pelvis and other parts of the skeleton may be expected to conform to the types at Stuttgart and Tübingen. The shaft of the femur is much straighter than in *Megalosaurus*, and the other characters all tend to remove the genus *Avalonia* from the types in which the pubic bones are slender and rod-like, and refer it to types in which those bones are flattened plates.

Only 16 inches of the proximal end of the left tibia is preserved. The proximal end is greatly expanded, especially towards the anterior crest of the bone. The proximal surface is truncated in the usual way, and is triangular. It measures 12 inches from front to back, and 9 inches from side to side behind, indicating, as the femur is nearly a foot wide, that the fibula had the usual slender form. The inner side of the bone is smooth and convex from front to back; the fibular side has a shallow channel for the fibula. The posterior side is concave in the middle width at the proximal end. These characters are too few to greatly elucidate the characters of the animal, but they are in harmony with the proximal end of the tibia in the genera which have resemblances to the femoral bone.

The hind foot is evidenced by digital and terminal claw phalanges. In all characters these bones are so remarkably like those which I have figured in *Euskelesaurus* (Annals Nat. Hist., ser. vi, vol. xiv, p. 332, 1894) that I can point to no differences between them. The transverse width of the claw phalange removes the animal from all allies of *Megalosaurus*. It is not quite so wide as the same bone in *Cetiosaurus*, and conforms to the type of *Zanclodon* preserved at Tübingen. The digital phalanges are $2\frac{2}{10}$ inches long, as wide behind, narrower in front; $1\frac{8}{10}$ inch deep behind, depressed in front. The bone narrows superiorly, and has the trochlear extremities completely ossified. The claw phalange exceeds 4 inches in length, being more than one-tenth of the length of the femur, and nearly twice the length of a penultimate phalange. Its articular end is trapezoidal, fully 2 inches deep, and as wide below the middle. The usual vascular grooves extend in arched curves along the sides of the bone, and are continued transversely beneath the articular end. The limb bones probably indicate an animal less than six feet high.

The vertebræ preserved appear to indicate two animals. The dorsal vertebræ all agree in the anterior face being flattened and relatively small, while the posterior face is concave and much larger. In this they resemble the vertebræ of *Avalonia*. But since one type has the centrum 5 to $5\frac{1}{2}$ inches long, with the anterior face 6 inches deep, while the posterior face is 8 inches deep, I conclude that it indicates a distinct animal from the second type, in which the centrum is $5\frac{1}{2}$ to 6 inches long, with the articular faces vertically ovate instead of circular, $4\frac{1}{2}$ inches deep in front, and 5 inches deep behind. After making all allowances for the effects of compression and distortion, I am compelled to refer the larger vertebra to the animal with the larger tooth, and suppose that the animal with the smaller tooth was represented by the smaller dorsal vertebra. The large size of the centrum exceeds

anything seen in British carnivorous saurians, and is especially large as compared with the dorsal vertebræ of *Megalosaurus*, in which the vertebræ are as unlike the fossil as are the limb-bones.

The large dorsal vertebra of *Avalonia Sanfordi* is somewhat crushed, and has the body of the centrum unusually constricted, both at the sides and the base. Above the middle of the side, and a little behind the middle length, is a concave impression, pinching the sides till they are about 3 inches apart. The flattened anterior face is not well preserved, and the margin of the deeply concave posterior face is rounded. The measurements indicate a moderate arching of the back. The neural canal is $2\frac{6}{10}$ inches high in front and 2 inches wide; behind it is wider than high.

The neural arch has a strong elevated capitular facet 2 inches deep and $1\frac{1}{2}$ inch wide, vertical and flat, with the anterior border straight and the posterior border convex. It is an elevation upon and expansion of the anterior buttress of the arch, just as the tubercular facet (which is lost with the transverse process) is supported by the posterior buttress, which is a narrow oblique ridge. Hence there is a concavity between the facet and the ridge, which extends under the transverse process. The large posterior zygapophyses extend back beyond the neural spine; and the buttresses below them, which face obliquely outward and backward, are excavated for the reception of the pre-zygapophyses. The neural spine is compressed and vertical, about 3 inches from back to front and half an inch thick, though there is no certain indication of its height. The transverse width over the neural arch as indicated was ten inches. The height of the vertebræ up to the summit of the neural spine may have been 20 inches. The transverse elevation of the capitular facet an inch above the base of the neural arch is a remarkable and distinctive character. The large size of the vertebra is somewhat Cetiosaurian.

The ribs were strong: one fragment, more than 15 inches long, is 3 inches deep at the fracture towards the proximal end, where the external surface is reflected somewhat backward, and as the rib extends outward its plane becomes twisted, so as to present a wider and oblique lateral superior surface, the measurement being about $1\frac{1}{2}$ inch at the fracture at the distal end.

The remainder of the vertebræ are referred to *Picrodon Herveyi*. They comprise dorsal vertebræ, with the body of the vertebræ compressed from side to side, and relatively more elongated, but with the front of the centrum narrower than the back. There is a distinct suture between the neural arch and the centrum. And the neural arch has strong upwardly converging buttresses, supporting the transverse processes. The articular faces are deeper than wide; the width does not exceed $4\frac{1}{2}$ inches.

A caudal vertebra, showing the base of the transverse process, has the centrum about 5 inches long, and the base of the transverse process $2\frac{1}{2}$ inches from front to back, by $1\frac{1}{4}$ inch deep. The articular face is about 5 inches deep, by less than 4 inches wide, but the preservation does not show whether chevron bones were developed at the hinder border. A later caudal, with the articular surface

fully $2\frac{1}{2}$ inches deep and the centrum 4 inches long, has no transverse process, and shows no indication of a chevron facet, though the base of the articulation is somewhat thickened behind. A still later vertebra has the centrum 3 inches long, and the articular face $1\frac{1}{3}$ inch deep by $1\frac{1}{10}$ inch wide. The caudal vertebræ continue to diminish in length, and the neural arch becomes compressed from side to side, but remains well developed, and nearly an inch longer than the centrum. The pre-zygapophyses look obliquely upward and forward, and receive the wedge of the posterior zygapophyses between them. There appear to be faint indications of very small chevron bones in these latest vertebræ. It is possible that the smaller caudal vertebræ belong to *Avalonia*.

These vertebral characters indicate an animal closely allied to *Avalonia*, but well distinguished by the lateral compression of the centrum, supported by the singular form of the tooth crown, obliquely serrated at the margin, and ribbed on the inner side.

EXPLANATION OF PLATE I.

Avalonia Sanfordi, Seeley.

Fig. 1.—Anterior aspect of left femur. *a*, articular head; *b*, ridge representing the trochanter major; *c*, broken base of the inner lateral trochanter; *d*, inner of the larger distal condyle.
Fig. 2.—Posterior aspect of a dorsal vertebra.
Fig. 3.—Right side of a dorsal vertebra, showing (*f*) the capitular and (*t*) tubercular facets, and the xygapophyses.
Fig. 4.—Side view of claw phalange and penultimate phalange of hind foot.
Fig. 5.—Articular end of claw phalange.

Picrodon Herveyi, Seeley.

Fig. 6.—Dorsal vertebra, posterior aspect.
Fig. 7.—Same vertebra, lateral aspect.
Fig. 8.—Early caudal vertebra, lateral aspect.
Fig. 9.—Late caudal vertebra.

Rhætic Beds: Wedmore Hill (Vale of Glastonbury), Somerset.

See also note on some Rhætic Foraminifera from Wedmore, by F. Chapman, 1895, Ann. and Mag. Nat. Hist., vol. xvi, p. 305.

II.—Recent Observations on European Dinosaurs.

By Professor O. C. Marsh, M.A., Ph.D., LL.D., F.G.S.;
of Yale College, New Haven, U.S.A.

During the past summer, it was my privilege to attend the International Congress of Geologists at St. Petersburg, as an official delegate from the United States, and this gave me an opportunity to see a number of museums and collections in Europe which I had not before visited. I thus had the privilege of inspecting personally many interesting reptilian remains that I had not previously known, and of examining others which were more or less familiar to me from figures and descriptions.

In the present paper, I have only time to speak of the Dinosaurs, in which I have long taken a special interest, and have endeavoured to study all the known specimens of importance, both in this country and in Europe, having in view the preparation of a series

of memoirs on the different groups of this subclass of extinct Reptilia.

London.—I began my investigations in the British Museum in London, a great treasure-house for fossil reptiles, to which I have long made frequent pilgrimages. This time the Dinosaurs were seen to better advantage than ever before, but of new or unknown forms I found that few had been added to the collection since my visit two years ago; and I consoled myself with the other extinct Reptilia, and especially with the new fossil birds and mammals from South America.

St. Petersburg.—In St. Petersburg I hoped to find many Dinosaurian remains, as here had been brought together an abundance of fossil treasures from various parts of the Russian Empire, which I knew must contain many forms of this group. In the four principal museums of the city, however, I could find no bones of Dinosaurs on exhibition, nor could I learn from any of the museum authorities that such remains had been recognized among the specimens received, neither could I find any such fossils myself among the débris of the collections, so often a rich repository for new or inconspicuous specimens. This was true also of the smaller collections visited, and I was at last forced to admit that here, at least, the Dinosaurs of Russia, like the snakes of Ireland, were conspicuous only by their absence.

Moscow.—This opinion was not changed by a visit to the rich geological collections of Moscow, which I examined with care; although other fossil vertebrates, including many reptiles, were abundantly represented. I was assured, moreover, by various Russian palæontologists, that in other museums of the empire or in the known localities they had seen no Dinosaurian remains. This vain quest, however, only proves that the discoveries are yet to be made, and I confidently expect them at no distant day, since in almost every other part of the world Dinosauria have already been brought to light. In Northern Europe west of Russia, and in North America to the east, these reptiles were especially abundant, and the vast territory intervening must contain numerous Dinosaurs, including many new forms of the group.

Vienna.—In Vienna I knew that my friend Professor Suess had a large collection of Dinosaurs in his museum to show me, and I spent several days there in their investigation. This collection was of special interest to me, as it was from the Gosau fresh-water deposits, which, as a student, years ago, I explored mainly in the expectation of finding Cretaceous mammals; and I was not without hope of still detecting such remains during my present visit, as here were the localities where they were, in my judgment, most likely to be found in Europe. The Dinosaurs I examined were from Neue Welt in this formation, and were of great interest. They had all been studied by Bunzel, Seeley, and others, who had recognized ten or twelve distinct genera and many species among them. I could find, however, not more than a quarter of this number, and among these I found no indications of the *Ceratopsia*, which from

the published figures and descriptions I supposed to be represented in this collection. The Dinosaurs with dermal armour which I saw all pertained to the Stegosauria, and two distinct genera among them were more nearly like *Scelidosaurus* of the English Jura and *Nodosaurus* of the American Cretaceous than any others with which I am familiar. This collection contained the only Dinosaurian remains I could find in Vienna.

Munich.—I next went to Munich, which, under Professor von Zittel, has become a great centre for palæontology. I found that the gem of the collection is still the unique *Compsognathus*, which in several previous visits I had studied with care. A re-examination impressed me even more with the fact, that this is one of the most perfect and interesting vertebrate fossils yet discovered, and no other example of the genus is known. It was in this unique specimen that years before I had detected the embryo, and this fossil still affords the only known evidence that Dinosaurs were viviparous. I could find no other Dinosaurian bones of interest in the Munich collection, the new features being mainly numerous fine specimens of Mosasauria from America, and some interesting remains of *Hesperornis* and *Baptornis* from the same horizon in Kansas.

I was much pleased to see here the new Jurassic fossils collected by Nansen in 1896, at Cape Flora, in Franz Josef Land. These interesting remains are now under investigation by Dr. J. F. Pompeckj, assistant in the Munich Museum. I could detect no vertebrate fossils among them, although various indications favour their presence in this fauna.

Paris.—My limited sojourn in Paris gave me no opportunity for a careful examination of the museums there, but I could learn of no recent additions of Dinosaurian remains since my last visit.

Caen.—I next went to Caen, in Normandy, to see the famous Dinosaur *Poikilopleuron*, so well described by Deslongchamps many years ago. Through the kindness of my friend Professor A. Bigot, I had a good opportunity to study this unique specimen, which of late has been regarded as identical with the *Megalosaurus* of Buckland, the first genus of Dinosaurs described, and one about which little is yet known.

Among the undetermined material of this museum, I was greatly pleased to find the genus *Pleurocœlus* well represented by characteristic fossils, and from a well-defined Jurassic horizon in the vicinity of Havre. The species appears to be a new one, somewhat smaller than *Pleurocœlus suffosus* from the Kimmeridge of Swindon, England.[1] It resembled still more closely *Pleurocœlus nanus*, which I have described from the Potomac formation of Maryland.

Pleurocœlus is one of the most characteristic genera of the Sauropodous Dinosauria, and its value in marking a geological horizon should therefore have considerable weight. It is now known from the two European localities mentioned above, both in strata of undoubted Jurassic age. The same genus is well represented in

[1] Lydekker records a Wealden species, *Pleurocœlus valdensis*, in Quart. Journ. Geol. Soc., 1890, vol. xlvi, p. 182, pl. ix.

the Potomac deposits of Maryland, and has been found also in the *Atlantosaurus* beds of Wyoming, thus offering, with the associated fossils, strong testimony that the American and European localities are in the same general horizon of the Upper Jurassic.

Havre.—The last day at my disposal before sailing for America, I spent in Havre, in the Muséum d'Histoire Naturelle, where the director, M. Lennier, showed me many vertebrate fossils of interest, from the well-known localities near the city. Here, again, among the fragmentary specimens not yet investigated, I found the bones of another Dinosaur, also one of the Sauropoda, but considerably larger than the *Pleurocœlus* at Caen. The remains were very similar to those of *Morosaurus*, and the horizon was in the Kimmeridge, which is here well defined.

From Havre, I crossed the Channel to Southampton, and with a parting look at the Wealden cliffs of the Isle of Wight, which have furnished the remains of so many interesting Dinosaurs, I sailed for home.

III.—Narrative of a Geological Journey through Russia.

1. Finland.

By Geo. F. Harris, F.G.S., M.S.G.F., etc.

THE meeting of the International Geological Congress at St. Petersburg towards the end of August last year was about as successful in promoting the main objects the Congress has in view as any of its predecessors. There was a marked absence of anything like a serious radical programme, and in that sense the meeting may be said to have been progressive. The majority of the papers read were commonplace, the few exceptions being mostly in the domain of petrology. Every geologist who attended the meeting was grateful to the Organizing Committee for getting together such a nice little exhibition of specimens, maps, and models for the occasion. It was full of interest.

The official Russian geologists did everything in their power to assist their visitors. They caused certain scientific institutions in St. Petersburg to remain open longer than usual, and were never tired of explaining the rich collections stored in the geological and mineralogical museums in the Imperial University, and in kindred museums. During the week of meeting they organized a day's excursion to the Czar's palace at Peterhof, and another to the renowned falls of Imatra—a long distance off, in Finland, but distance counts as nothing in the Russian Empire. Then there were the inevitable receptions, though, fortunately, these were not carried out to the same extent as at the Washington Meeting.

But it was not of the actual Congress meetings, nor of the papers read or mumbled before them, nor of the wonderfully preserved mammalian remains in the temporary museum, nor of the unvarying courtesy of the Russian officials, that I desire to write in these articles. Neither may I say anything in the Geological Magazine concerning the social aspects of our visit to the other side of Europe

—of the many banquets held in our honour, of the terrible number of speeches, mostly by self-elected "representative" spokesmen, which frequently commenced shortly after the soup was placed upon the table (so keen was the competition to do justice to our hosts!): these and many minor incidents, some of a distinctly sensational character, would more fittingly be recorded in the pages of a three-volume novel.

The Committee of Organization had arranged that four excursions should take place in connection with the Congress meeting. Of these, three were to be held before the meeting, viz.:—(1) to the Urals, (2) to Esthonia, (3) to Finland; and one after, namely (4) to South Russia, by the Volga or alternative routes, over the Caucasus through Tiflis to Baku (variations), thence to Batoum and across the Black Sea, through part of the Crimea to Sebastopol, and on to Odessa. I had the good fortune to be included amongst the participants of journeys 3 and 4—to Finland and Transcaucasia; and the aim of these articles is to give some account of the geology along the lines of route pursued by those two parties. To begin with the Finland journey; and I prefer to write in narrative style.

Starting from St. Petersburg at night-time for Helsingfors, we had no opportunity, then, of learning the character of the scenery through which we passed. The next morning broke dull and grey, and through the rain we could see that although the country was flat it was extremely well wooded, and that the fields adjacent to the railway track were strewn with enormous boulders. The country was saturated with water, and the bracken fern and undergrowth generally were doing their best to hand plenty of peat down to posterity. Here and there was evidence of disastrous forest fires, whilst numerous blackened stumps stood out of the peaty soil and could be counted by hundreds in the clearings. Vegetation was not only abundant, but luxuriant, and this in what is usually called cold, icy Finland! And so we continued to Helsingfors, meeting with but little else by the way except an occasional outcrop of granite.

At Helsingfors, Wilhelm Ramsay, of the University of that city, met us. This indefatigable geologist has done much for the geology of the country adopted by his ancestors. His work in the Isle of Hogland[1] and on the Quaternary deposits of Finland[2] may be cited as examples, whilst he has written joint memoirs with H. Berghell[3] and E. T. Nyholm[4] on the petrography and stratigraphy of the older rocks of Finland.

Helsingfors stands at the extremity of a small promontory, which is composed of a heterogeneous mass of what, for want of a better

[1] "Om Hoglands geologiska byggnad": Geol. Fören. Förh. Stockholm, Bd. xii, 1890. "Beskrifning till kartbladen, No. 19 och 20, Hogland och Tytärsaari": Finl. Geol. Und. 1891.

[2] "Ueber den Salpausselkä im östlichen Finnland," Fennia 4, No. 2; Helsingfors, 1891.

[3] "Das Gestein von Iiwaara in Finnland": Geol. Fören. Förh. Stockholm, Bd. xiii, 1891, p. 300.

[4] "Cancrinitsyenit und einige verwandte Gesteine aus Kuolajärvi": Bull. Comm. Géol. de la Finlande, No. 1, 1895.

name, is called gneiss or "granitic schist," and the same class of rock extends for many a square mile around, relieved only by considerable extensions of overlying Glacial and Post-Glacial clays, and sands. The gneiss is believed to be of Archæan age. It is an indescribable mixture, the so-called foliations resembling flow-structure, leading one to the belief that the whole was due to contact metamorphism. In certain cases, where schistose fragments appear to have been more or less absorbed, such an explanation is highly probable; but, except the "Rapakivi," practically all the granite of South Finland, for at least 200 square miles, is foliated or "gneissose," or "schistose." Over large tracts appearances are certainly in favour of differential movements in the magma. But I will not say much about the rock, for our opportunities of examining it in the field were very small. The islets which add so much to the beauty of the environs of the Finnish capital are constituted either of this gneiss or the "gneissose granite."

The courteous Director of the Geological Commission of Finland, Mr. J. J. Sederholm, invited us all to the offices of the Survey, where he had prepared a representative collection of rocks and minerals, and examples of such fossils (all Quaternary) as have been found in the country. Sederholm's contributions to geology are already important. Amongst other things he has prepared a small geological map of Finland in two editions—solid and drift. He has especially studied the "Rapakivi"[1] and Archæan[2] rocks of South Finland. During the past year or two he has been engaged on the detailed mapping of the extremely interesting country in the neighbourhood of Tammerfors.[3] In conjunction with W. Ramsay, he prepared the useful guide[4] for the use of members attending the Finland excursion.

The collection of specimens at the office of the Geological Commission proved very interesting, and, in a measure, served as an illustrated guide to the class of rocks which we were to study in the field during the following week. Many types, however, did not lie along our track; amongst these latter were marvellous examples of "rapakivi" and some "globular" granites, and a word or two respecting them may not be out of place.

The peculiar kind of "granite" known as rapakivi has, typically, a number of large phenocrysts, commonly rounded or ovoid, composed of a kernel of orthoclase enclosed within an envelope of oligoclase (Fig. 1). The rock between these phenocrysts is fine-grained and frequently micropegmatitic. The formation of the acid

[1] "Ueber die finnländischen Rapakiwigesteine": Tscherm. Min. und Petrogr. Mitth. Wien, Bd. xii, 1891.

[2] "Archäische Eruptivgesteine a. d. südwestlichen Finnland": id., Bd. xii, 1891. "Ueber einen metamorph. präcamb. Quarzporphyr von Karvia, Provinz Åbo": Bull. Comm. Géol. Finlande, No. 2, 1896; etc.

[3] "Archäische Sedimentformation im südwest. Finnland": Bull. Comm. Géol. Finlande, No. 6, 1897.

[4] "Guide des excursions VII Congrès Géol. Internat.: XIII, Les Excursions en Finlande"; St. Pétersbourg, 1897.

before the more basic felspar in the phenocrysts, and the detailed structure accompanying that phenomenon, form a very instructive study.

At the same time, the term rapakivi is largely applied by the geologists of Finland to holocrystalline rocks of granitic type

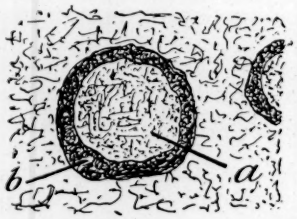


FIG. 1.—"Rapakivi granite" ($\frac{1}{3}$ nat. size). *a* = orthoclase; *b* = plagioclase.

which contain large, rounded, and even irregularly-shaped phenocrysts of orthoclase, and which may not have the triclinic felspar wrapping round them, except in very rare instances in any one *massif*. It is used, in fact, as a general field term for granites of that description of Pre-Cambrian age. As thus defined, "rapakivi granite" extends over enormous areas in Southern Finland, on the north-eastern shore of Lake Ladoga, in the little island of Hogland in the Gulf of Finland, and in the Åland archipelago. It is one of the youngest of the Pre-Cambrian eruptives in the country, and has been classified by Sederholm [1] in his Jotnian formation—the younger subdivision of the Algonkian (or Archæozoic) group.

The "globular granites" exhibited at the offices of the Geological Commission (some of which were subsequently shown in the temporary museum formed in connection with the Congress meeting at St. Petersburg) have been described in some detail by Benjamin Frosterus.[2] The accompanying diagram (Fig. 2) represents one of these rounded or ovoid bodies. Mr. Frosterus tells me that the kernel is frequently formed of a fragment of biotite schist. Following his observations in the work just quoted, it will be seen that, normally, there is a kernel or nucleus, outside of which are four successive zones. In the diagram (Fig. 2) *a* represents the nucleus, which, in the specimen analyzed by Frosterus, contained 63·64 per cent. plagioclase (Ab_2 An_1) with 18·92 of biotite and 19·60 of quartz. Then followed the first coating or andesine zone (*b*), in which the plagioclase (Ab_4 An_3) amounted to 73·22, biotite 8·00, and quartz 16·50. The next coating, the oligoclase-andesine zone (*c*), yielded plagioclase (Ab_1 An_1) 56·07, biotite 5·60, and quartz 39·72. This is succeeded by a microcline zone (*d*), in which we have plagioclase (Ab_3 An_2) 16·52, alkali-felspar 57·44, and

[1] "Guide des Excursions," etc. (op. cit.), p. 18.

[2] "Kugelgranit von Kangasniemi in Finland": Bull. Comm. Géol. Finlande, No. 4, 1896.

quartz 26·74. The outermost zone (*e*) has plagioclase (Ab_2 An_1) 44·28, alkali-felspar 6·79, biotite 4·00, quartz 42·82. The mineral composition of the stone between the globular bodies is plagioclase (Ab_2 An_1) 35·49, alkali-felspar 16·88, biotite 12·27, quartz 32·53. From this and from the chemical composition of the different zones and the "muttergestein," it is evident that the general tendency of the ordinary separation of the crystals from the original magma was normal—that the zones, on the whole, become more acid as they recede from the nucleus. The proportion of $Si\ O_2$, for example, in zone *b* is 61·64, *c* 72·92, *d* 74·80, and *e* 75·67, whilst the rock between the globular bodies has 70·46. Not the least interesting feature in these remarkable bodies is the mechanical deformation to which they have occasionally been subjected, and which has had the effect of breaking through the zones and squeezing out some of the substance of the interior. In certain of these Finnish "globular granites" shown at Helsingfors the spheroidal and ovoid bodies have been partially absorbed by the matrix in which they occur. The concentric zoning is clearly marked, and in most cases the minute crystals are so arranged as to produce a radiating effect.

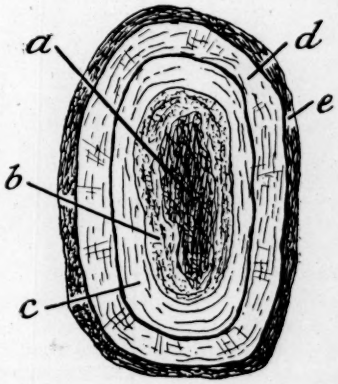


Fig. 2.—"Globular granite." Diagram showing disposition of zones in one of the typical ovoid bodies (about ¼ nat. size). The distinguishing italics are explained in the text.

The structure of these bodies differs somewhat from that of the well-known spheroids in the granite of Mullaghderg, County Donegal, described by Dr. Hatch,[1] though the Finnish rock agrees better with the Irish than with certain Continental rocks adverted to by the last-mentioned author.

At length, after a stay of three days, it was time to leave Helsingfors, and Mr. Sederholm took charge of the party. A long railway ride north, to Tammerfors, and an enthusiastic welcome from

[1] Quart. Journ. Geol. Soc., vol. xliv, 1888, p. 548 et sqq.

the inhabitants of that manufacturing town were the first items on the programme. The country seen on the way was flat or but slightly undulating, with low hills occasionally; the whole well wooded and watered. The Glacial clays passed through shortly after starting were here and there covered by Post-Glacial clays and littoral deposits containing *Litorina, Cardium, Mytilus, Tellina,* etc. A ridge of considerable size was traversed by the railway at Hyvinkää, which proves to be a large terminal moraine. To the north of that place moraine gravels predominate, and there are several åsar, a phenomenon which I intend to describe more particularly at another stage of our journey. Then several lakes come into view, and Tammerfors with its hilly scenery is reached.

Tammerfors is situated on a narrow neck of land formed by an "ås," which separates the lakes of Näsijärvi and Pyhäjärvi. The former lake is about 58 feet above the latter, and the two are connected by rapids, which in parts are very beautiful. The journeys for the next two or three days were from that place as a centre, a special train being always at our disposal.

The neighbourhood of Tammerfors is excellent for studying the Archæan rocks of Finland. The following divisions are recognized by Mr. Sederholm[1]:—

1. Post-Bothnian granite.
2. Bothnian schists.
3. Pre-Bothnian gneiss.

In the last division, granites (essentially metamorphic), porphyroides, and closely foliated gneiss predominate. These latter, according to Sederholm, are granitized mica-schists. All these rocks crop out to the south of the town.

We examined the foliated granite and mica-schist (on the afternoon of our arrival) in a railway cutting at Siuro, about twenty miles west of Tammerfors; and in a railway cutting to the west of Suoniemi we had an opportunity of examining the mica-schist highly plicated. The micro-structure of these and some other Finnish rocks will presently be described.

We will turn now to the second division—the Bothnian schists, which, as will be seen as this narrative proceeds, we examined at many points. The local development of these is known as the Tammerfors schists. They crop out in bands running east and west, the whole being highly inclined and limited by the Pre-Bothnian gneiss on the one hand and the enormous outcrops of the Post-Bothnian granite on the other. These schists are often represented by phyllades,[2] which occasionally approach true argillites and sometimes pass gradually into fine-grained mica-schists. The foliated arkose, which Mr. Sederholm calls "leptite" (to be more particularly referred to hereafter), occurs in this subdivision. So also do certain hornblende (mostly uralite) schists (called porphyritoides), which were originally volcanic tuffs, and sometimes have altered lavas intercalated between them.

[1] "Excursions en Finlande" (op. cit. supra), p. 2.

[2] This term is here used in its broad sense.

But one of the most remarkable features of the "Bothnian schists" in the neighbourhood of Tammerfors is the presence of conglomerates on several horizons. These, in many instances, are so fresh that one finds some difficulty at first in believing that they are really Archæan. The waves of Lake Näsijärvi, in the lovely bay of Hormistonlahti, where these conglomerates are well exposed, have assisted the atmosphere in picking out the more or less crystalline cement between the pebbles. In other situations these Finnish rocks reminded me strongly of certain Cambrian conglomerates in North Wales; but I do not desire to draw the comparison any closer, for the Cambrian of the neighbouring parts of Russia, as everyone knows, is peculiar as being so little affected by the ravages of time.

Mr. Sederholm places[1] the thickness of the Tammerfors schists at from 4,000 to 5,000 mètres—2,000 mètres for the phyllades, 1,500 for the lower tuffs and conglomerates, and the remainder for the upper tuffs with their intercalations of phyllade and conglomerate.

The Post-Bothnian granite, which crops out to the north of the schists in the Tammerfors area, is shown by Sederholm to traverse the latter, veins being thrown out at certain places, and large pieces of the schists being caught up at frequent points along the junction between the two rocks. And these pieces of included rock, in addition to possessing the structure and mineral composition of the Tammerfors schists, have occasionally been discovered to contain typical pebbles as found in the last-mentioned formation.

As I proceed with the narrative, I propose to give field notes and some account of the micro-structure of examples of these Archæan rocks which I collected, and to deal with the Glacial deposits, in the next article.

(*To be continued.*)

IV.—Notes on some small Lake-basins in the Lepontine Alps.

By Prof. T. G. Bonney, D.Sc., LL.D., F.R.S., V.P.G.S.

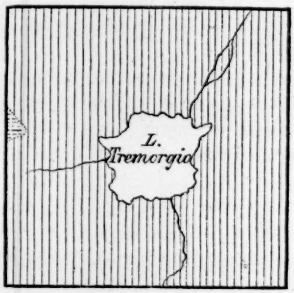
ROCK-BASINS have been getting out of favour of late. The "heckling" which they have suffered from my friend Mr. Marr tempts one to echo Betsy Prig's classic remark about Mrs. Harris. Mr. Brend, however, though "dealing faithfully" with them in the September number of the Geological Magazine, does permit one or two to exist on sufferance, so that I feel minded, were it only as an act of charity to these depreciated securities, to describe two or three examples in the Alps which I think must be true rock-basins.

The first is called the Lago Tremorgio.[2] It lies, at a height of 5,997 feet above the sea, on the southern flank of the Val Bedretto, at the top of a long and steep ascent from Fiesso. It is slightly irregular in outline, but circular in form, with a diameter between

[1] Op. cit. supra, p. 4.
[2] I examined it in 1893.

seven and eight hundred yards. It is almost enclosed by steep slopes and crags, and is entered through a narrow V-shaped gully, with a rapidly rising ridge on either side. Through this gully runs the stream which carries off the water of the lake. I followed a track which mounts gradually up the right bank, and no blocked outlet exists on that side; I had an excellent view of the other bank, and feel certain there could not be one there. In fact, the rapid rise of the rocky ridge on either side and its outline are almost conclusive to an eye accustomed to mountain forms against there

South.



North.

Fig. 1.—Broken horizontal lines: Gneiss.
Vertical lines: Schists, micaceous, etc.
White: Water.
(Scale as below, Fig. 2, on p. 17.)

being any outlet to the cirque but the present one. At this the live rock can be seen not only on either side but also in the bed of the stream. Of that I could be sure, because the channel had been deepened, apparently in order to add slightly to the pasture-land by lowering the level of the lake, and had been cut down for about four feet into the solid rock. Above the cliffs is an undulating tract of pasture, forming a kind of step, on which is a small shallow tarn, and from this rocky slopes lead to the crest of the range, the lowest part of which, at the Passo Campolungo, is 7,595 feet above the sea. Thus the Lago Tremorgio is enclosed between two lofty spurs from the range, somewhat in the position of the seat of an armchair.

The next rock-basin, the Lago Ritom[1] in the Val Piora, is on the opposite side of the Val Bedretto, at almost exactly the same elevation above sea-level.[2] Its position is remarkable. A mass of crystalline schists, calcareous, quartzose, and micaceous, with some overlying rauchwacke, are apparently infolded between two masses of gneiss, of which the southern forms a high spur separating the Val Piora from the Val Bedretto, and the northern belongs to the watershed of the Lepontine Alps. Thus the Val Piora occupies a kind of trough between these two masses of gneiss, which runs

[1] I was there for some time last summer, and had already paid four short visits.
[2] It is a few inches over 6,000 feet.

almost from east to west, and its upper end descends from a bold craggy peak, which is called the Pizzo Columbe, and is formed of dolomitic limestone (a variety of the rauchwacke). On either side of this peak gaps, about 7,800 feet in height, lead to the upper part of the Lukmanier Road. After the first descent from these passes, the bed of the valley falls rather gradually and is fairly open, the mountains rising with moderate steepness on the southern side and precipitously on the northern. Sheltered in a recess in the latter side, just before we reach a break in the level of the valley, we find the Lago Cadagno (6,303 feet). It occupies a kind of cirque or gigantic corrie. Steep crags of gneiss sweep round about one half of it;

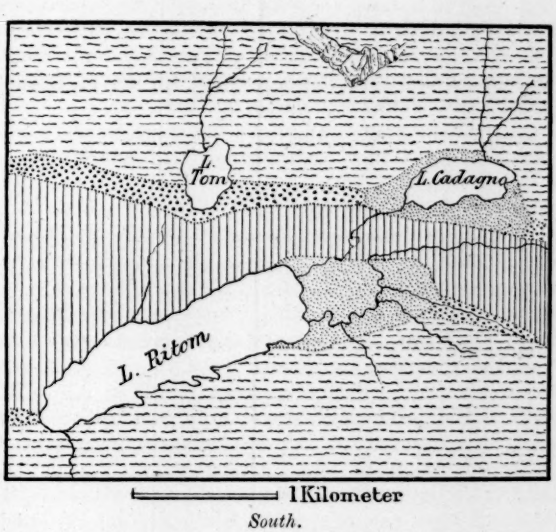


Fig. 2.—Broken horizontal lines: Gneiss, with garnet and actinolitic schists (in northern part).
Vertical lines: Schists, micaceous, quartzose, and calcitic.
Coarse dotted: Rauchwacke.
Fine dotted: Alluvial.
White: Water.

the western end is barred by a spur, formed of an infold of rauchwacke, followed by a mass of dark micaceous schist; the former corresponding with a slight depression, the latter with a hill. The lake is nearly 900 yards from east to west, but a small marshy plain shows that it has once extended rather farther in the latter direction; it is about 275 yards across. The stream draining it flows from the south-west end. The character of the ground makes it difficult to speak positively, and one or two low mounds near the stream may be morainic, but the minor ridges in the neighbourhood of the more open side are clearly live rock, and the stream itself passes over the same at a level a very few feet indeed

below that of the lake. Hence, even if the latter to some extent is retained by drift, it may nevertheless, since it is not very shallow, be claimed as a rock-basin.

A short distance from the Lago Cadagno, the level of the valley, as already stated, is interrupted by cliffs and craggy steep slopes, at the bottom of which lies the basin of the Lago Ritom, in shape something like a shortish straight sausage. The part occupied by water is rather more than two thousand yards in length, and on an average about a quarter of the width;[1] the upper end, now a grassy meadow traversed by streams, is rather less than a thousand yards long. The basin is bounded on the southern side by a range of gneiss—forming here the northern boundary of the Val Bedretto—which descends with moderate steepness to the lake, and slightly indents the margin of the latter with the openings of its shallow valleys. Steep grass slopes and crags of micaceous schist, becoming more precipitous towards the north, form the head of the basin, and a line of crags, at about the same elevation, extends nearly to the lower end of the delta, where they are merged in the steep slope. The basin, indeed, is bounded on all the northern side by steep grass slopes and high cliffs, outposts of the central range of the Lepontine Alps. The part visible from below consists of the dark micaceous schists,[2] already mentioned. The lake-basin, in fact, lies obliquely across the zone of these rocks; its upper end being not far from their northern boundary, its lower just at the southern limit. As this is approached, the slopes continue steep; the schists pass away across a range towards the lower end of the Val Canaria; the lowest part of the crest, where also some rauchwacke occurs, lying between the Pian Alto (7,428 feet) and Fongio (7,257 feet), perhaps four or five hundred feet below the latter. This mountain is chiefly composed of gneiss, and is in reality a prolongation of the gneissic range which, as already mentioned, forms the southern bank of the Lago Ritom. There the valley in which that lake lies makes at this point a sharp turn to the south, and the water is discharged through a very narrow glen—a mere gateway in the mountains; for within a few yards of the foot of the lake the stream leaps down towards the Val Bedretto in a grand series of cascades. This is practically unbroken for some hundreds of feet, since the craggy slope is extremely steep to below the hamlet of La Valle. At the above-named gateway, close to the Hotel Piora, rock can be seen on either side of the stream, obviously forming its bed. A glance at the mountains on either side shows the existence of any other outlet to be impossible. So the Lago Ritom must occupy a true lake-basin, and that a fairly deep one.

[1] Professor Forel has kindly informed me that it is 2,000 mètres long, 500 mètres wide, and 60 mètres in greatest depth. I am indebted to him for the measurements of Lago Cadagno and Tom.

[2] They belong to the group which for purposes of reference I have called the Upper Schist. They are described, as well as the geology of the Val Piora, in the Quart. Journ. Geol. Soc., xlvi (1890), p. 199, etc.

Putting aside for the moment some questions which arise from the physiography of its borders, I pass on now to a fourth lake situated on the northern flank of the Lago Ritom, at a considerably higher level. This flank, as I said, rises in cliffs and steep grass slopes. A path up the latter, near the side of a cascading stream, brings us into a small upland valley, and we presently reach a lake at its head called the Lago Tom (6,637 feet). Like the Lago Cadagno, it occupies a kind of cirque,[1] and lies in the strike of the same rocks, for the enclosing crags consist of similar amphibolitic and granatiferous gneiss, and at the lower end is rauchwacke, which can be traced from the southern side of the basin of the Lago Cadagno across the intermediate spur. But the Lago Tom is not only on a rock-basin but also on a very remarkable one. The lower end is dammed by a mass of rauchwacke, in shape something like a rude causeway. Its top, as a rule, is not less than 12 to 15 feet above the water, but in one place it is cut by a dry gully two to three yards wide. Still, the bottom of this cannot be less than six feet above the level of the water. Rather to the east of this gap a curving channel or inlet from the lake pierces into the barrier for some distance. Its sides are cliffs, which at its head are three or four yards high. Just on the other side of the barrier, a fairly copious stream breaks out in a shallow glen which continues the line of the dry gully already mentioned. This unquestionably drains the lake, but where it starts is not easily ascertained.[2] There is no distinct flow up the inlet already mentioned,[3] and yet the stream, within a few feet of its issuing from the rock (a bank of old snow concealed the actual outlet), is a yard or more wide and a few inches deep, running with a brisk current. I suppose, therefore, that the rocky bed of this inlet is traversed by a number of small fissures,[4] through which the water percolates, to be collected and carried off by the stream. The rauchwacke (the usual cream-coloured, rather soft, and broken-looking limestone) is exposed in so many parts of the barrier that the existence of a drift-blocked channel seems to me an impossibility, and the Lago Tom must occupy a true rock-basin.

Three out of these four lakes are situated within cirques or very precipitous corries, and if we suppose the main outlines of these to be anterior to the Glacial Age, the ice, as it descended from the ranges above, would impinge on the level floor, on which under these circumstances it might have some erosive force. The origin of the largest lake (Ritom) is less easily explained, unless we suppose that in all other respects the physical features of the neighbourhood remain practically as they were when it began to

[1] Its area is given as 1,000 square mètres, and it is said to be shallow. But I should think it would not be less than some 20 feet deep, and might be more.

[2] The only sign of disturbance in the lake itself, several yards away from the shore, was clearly an upward flow, i.e. was produced by a strong spring in the bed of the lake.

[3] I twice examined the surface of the water; on the second occasion (a very still day) I thought I detected a slight movement in some scum on the water.

[4] Rauchwacke often has a shattered, almost rubbly aspect.

be formed. The Val Piora, as I have said, consists of a lower step (the Lago Ritom) and an upper step, with which the Lago Cadagno is connected. These are separated by a rocky slope, precipitous in places, nearly 300 feet high. Supposing a glacier to be descending the Piora valley, we must assume this wall to be already in existence, or it could not acquire any plunging force, and even then the fall seems hardly adequate to produce the erosion of a basin like that of Lake Ritom. Possibly, however, the ice, just at this part, may have been "jammed"; for the main glacier was probably augmented by another ice-stream, which descended a shallow, but fairly well-marked valley, leading from a gneissic peak lying south-east down to the corresponding corner at the head of the Ritom basin; while the narrow "gate" by which the water is now discharged towards the Val Bedretto would block the mass of ice above it, and this would produce more than usual friction on the bed of the valley now occupied by the lake and its delta. This basin, then, the part which lies below the present contour-line of 6,000 feet (in round numbers), is the utmost that, in my opinion, can possibly be attributed to the erosive action of ice. Of this action, all the other dominant features in the surrounding scenery exhibit nothing more than superficial traces, and they appear to be due to the usual meteoric agencies.

The broad outlines of the Val Piora must have been determined at an early date. It lies, as I have said, in an infold of schists, belonging to the upper part of the crystalline series, and of some rauchwacke of Triassic age, which, after crossing the lower end of the Val Canaria, reaches the floor of the Val Bedretto at and near Airolo. Regarding this simply as a fold (it is really a complicated and faulted one), the natural line for the discharge of its drainage would be towards the Val Bedretto, in the direction of Airolo, passing over the col mentioned above as lying to the north of Fongio. The top of this col is probably about 6,800 feet above the sea. Fongio itself is clearly a prolongation of the gneissic range between the Val Piora and the Val Bedretto. Hence, at some very early date, differential movements in the mountain mass must have diverted the drainage of the Val Piora from a western direction to its present outlet on the east side of Fongio, through some chance dip already existing in the range. Owing to the rapid descent to the north a groove would soon be formed, and the direction of discharge finally determined. Since then, as I suppose, all of the lower half of the Val Piora that lies below the contour-line of 6,800 feet (in round numbers), with some of the upper, must have been excavated. Somewhat beneath this level, perhaps at about 6,500 feet, a rather marked increase of steepness is often perceptible in the slopes on the northern side of the lower part of the Piora valley. Besides this, a structure which is conspicuous in the Val Bedretto itself may not be without significance. Looking up that valley from such a point as the top of Fongio, one perceives that the slopes become near a certain part very much steeper, and begin to descend from that level rather abruptly towards the bed of

the valley. On the right bank of the Val Bedretto we can trace this terrace-like configuration for a long way below the opening of the Val Piora, and opposite to that gap I estimated its height as much the same as that of the pass north of Fongio, i.e. not far from 6,700 feet.[1] On the left bank, it will be remembered that, at the opening of the Val Tremola, the slope markedly changes, perhaps a thousand feet lower down.[2] I have observed this structure in many of the uppermost portions of the Alpine valleys, often some couple of thousand feet, perhaps occasionally rather more, above the present floor. It must indicate some very marked change in the erosive agents, probably an increase in the velocity of the torrents, since the valley becomes much more steep-sided. Can it possibly indicate the results of the Pre-Pliocene set of disturbances? But this is venturing into the realm of speculation; my present purpose is to show that, although doubtless many tarns and lakelets have no real claim to be called occupants of rock-basins, a few such do really exist.[3]

V. — On the Cretaceous Fossils found at Moreseat, Aberdeenshire.[4]

By A. J. Jukes-Browne and John Milne.

1. General Report by Mr. John Milne.

MORESEAT is in the parish of Cruden, in the east of Aberdeenshire. It lies at an elevation of 300 feet above sea-level, and the surface of the ground slopes to the sea at Cruden Bay, distant five miles to the south. On the north the ground rises gradually, reaching the height of 450 feet above sea in Torhendry Ridge, which is strewn with chalk-flints in great abundance.

Previous Investigations.—Geologists are indebted to Dr. William Ferguson, of Kinmundy, for the earliest notices of Greensand at Moreseat. In 1839 an excavation 14 feet deep was made for the water-wheel of a mill, and a drain away from it, on the south side of the farm steading, a little below the 300-feet level. The excavation was made in clay, and in it were found layers of sandstone containing many fossils. The Rev. J. Johnstone, Belhelvie, who lived at Moreseat at the time, says that the discovery excited great interest, and that Moreseat was visited by scientific men, amongst others by Professor Knight, of Marischal College and University, Aberdeen, who communicated with Dr. Thomson, of Glasgow University, on the subject, and informed his class

[1] The slope, above Fiesso, begins of course just below the Lago Tremorgio, or nearly at 6,000 feet.

[2] No doubt this has been subsequently cut down below the original level, the valley being a large one; the Val Canaria has been cut yet lower.

[3] I believe I know of others than those mentioned in this paper, but, as I have not examined them since Mr. Marr's paper was published, will not refer to them.

[4] Report of the Committee, consisting of T. F. Jamieson (Chairman), A. J. Jukes-Browne, and John Milne (Secretary), appointed to ascertain the Age and Relation of the Rocks in which Secondary Fossils have been found near Moreseat, Aberdeenshire.

of 1839–40 that Greensand had been discovered at Moreseat. Dr. Ferguson was a student in this class, and thus had his attention directed to the Moreseat fossils from the first. Hundreds of loads of clay were removed from the excavation, and many fossils were collected; but when the wheel was put in and built up, and the drain was covered up, there remained no trace of the interesting discovery.

In 1849, on making a deep ditch alongside a road to the north of the farm steading, and a little above the 300-feet level, the same clay, sandstone, and fossils were met with. Dr. Ferguson sent a notice to the Philosophical Society of Glasgow.[1] Next year he visited the newly-made ditch, and sent an account of the original discovery and a description of what he saw to the *Philosophical Magazine*.[2] Dr. Ferguson's description of what he saw is quoted here, because it exactly coincides with what was seen in subsequent excavations. "An excavation about 7 feet in depth was made, and the section presented irregular layers of unctuous clay, of a dark-brown colour and soapy feel, and so tough and adhesive as to render it a work of considerable labour to dig it out. Interstratified with this clay were thin layers of a compact sandstone. These layers of sandstone were not continuous; they graduated into each other, thinned out, disappeared, and reappeared most confusedly. They were very much inclined, dipping towards the south. The whole mass had much the appearance of having been drifted; although from the nature of the matrix, and the state of preservation in which the shells are found, it does not appear as if it could have been drifted far. The sandstone is tough and soft when newly dug, but hardens on exposure to the air and becomes light-coloured in drying. When wet, it presents a mottled appearance, the colour being greenish; when dry, this almost disappears."

In 1856 a collection of fossils from Moreseat made by Dr. Ferguson was examined by Mr. J. W. Salter and Mr. W. H. Baily. An account of them was published next year in the Quarterly Journal of the Society, along with a note by Dr. Ferguson. Mr. Salter regarded the Moreseat fossils as an indication, in the near neighbourhood, of Upper Greensand *in situ*. Types of these fossils are preserved in the Museum of Practical Geology, Jermyn Street, London.

In the memoir descriptive of the sheet of the Geological Survey containing Moreseat, notice is taken of the Greensand fossils found there, and of the Chalk-flint fossils found at Bogingarrie, a few miles to the south-west, also described by Mr. Salter; but the surveyor does not say that he saw at Moreseat any fossils or fragments of Greensand sandstone.

In 1894 the Secretary of the Committee was lecturing at Cruden on Geology and Agriculture for the Aberdeen County Council, and was induced by the mention of Greensand in the memoir to visit

[1] See Proceedings of the Society, vol. iii, 1849.
[2] See vol. xxxvii, 1850.

Moreseat and make inquiries; but he could learn nothing further than that fossils had been found in the excavation made for the mill-wheel, and as it was enclosed with masonry nothing could be seen. He visited the place repeatedly and examined all the ditches and watercourses on the farm, but found no fossils. The reason of this was seen afterwards. When pieces of the sandstone were exposed to frost they became a soft paste on thawing, and all trace of the fossils they contained disappeared.

He afterwards met with Mr. Alexander Insch, Peterhead, who had heard that fossils had been found north of the farm steading. Accompanied by him and Mr. D. J. Mitchell, Blackhills, Peterhead, he again visited Moreseat. An excavation was made to the north of the ditch seen by Dr. Ferguson, and after passing through a foot or eighteen inches of sandy clay, thin layers of sandstone with fossils were found. The appearance of the layers of sandstone was peculiar. They conveyed the idea that they were cakes of some plastic material spread out in a soft state, yet not wet enough to bear great lateral extension without cracking. The layers were full of vertical cracks, which broke them up into small fragments. These might have been caused by shrinking on drying, as the excavation was made where the ground would be dry in summer. The method of occurrence was the same as that described by Dr. Ferguson already quoted. The fossils found were chiefly casts of shells.

Specimens were forwarded to the British Association with an application for a grant of money to ascertain by deeper excavation whether the bed from which the sandstone had come could be found there. Though the application was unsuccessful, digging was continued by Messrs. Mitchell and Insch, who collected a large quantity of fossils in various places over an area a quarter of a mile broad in the neighbourhood of Moreseat.

In 1895 specimens were sent to Dr. H. Woodward, of the British Museum (Natural History), London, with another application for a grant from the British Association. A grant of £10 was given, and the Committee already named was appointed.

Professor J. W. Judd, of the Royal College of Science, South Kensington, was consulted about the specimens already collected by Messrs. Mitchell and Insch, and by his advice they were sent to the Geological Survey Office, where they were examined and compared with Dr. Ferguson's typical specimens by Mr. G. Sharman and Mr. E. T. Newton. They published a statement of the result in the Geological Magazine, Dec. IV, Vol. III, 1896, p. 247. They came to the conclusion that the specimens had "been derived from beds where a large part of the Cretaceous series of strata occurs; not only Upper and Lower Chalk and Upper Greensand, as pointed out by Salter, but also beds of Lower Greensand or Speeton Clay age." In making this statement they seem to have referred not only to the specimens collected by Messrs. Mitchell and Insch, but also to the Chalk-flint specimens in the Ferguson collection. It may therefore be noted that though flints are found

in great abundance on the ridge above Moreseat, they become fewer in going down the hillside, and are comparatively scarce at Moreseat, and it may be assumed that none of the flint-fossils in the Ferguson collection were found in the immediate neighbourhood of the Greensand fossils.

Work of the Committee.—On being made aware of their appointment the Chairman and the Secretary met on the ground, accompanied by Messrs. Mitchell and Insch. Mr. Johnstone, the proprietor of the farm, kindly consented to allow an excavation to be made. All the places where fossils had been found were examined, and it was resolved to sink a shaft at the highest place where they were certainly known to be, in the belief that the fragments of sandstone had been moved from a higher to a lower level. The place selected is on a knoll north of Moreseat, about 330 feet above the sea-level, and about a quarter of a mile from the place where fossils were found in 1839. The ground to the north is covered with peat-moss overgrown with heather, and nothing can be seen of its character. Half a mile to the north-east there is some cultivated land, and a pit had been sunk by a crofter for a pump in white unstratified siliceous matter, apparently detritus of chalk-flints. To the north-west another pit had been dug. At first glacial drift clay was met with, then fine stratified sand, unsuitable for a pump well, and the excavation was stopped at 14 feet deep. This hole was 50 feet above the site selected for the shaft. It was thought best to defer the sinking of the shaft till the following summer to avoid risk of obstruction from water.

Mr. J. T. Tocher, the Secretary of the Buchan Field Club, which is affiliated to the British Association, undertook to contract for the work, and along with Mr. Mitchell to visit it while in progress, and to examine the material excavated.

The shaft was dug in the summer of 1896, and a depth of 30 feet was attained. The first foot consisted of ordinary soil. Below it was found a yellowish-brown sandy clay mixed with small fragments of sandstone and pebbles of quartzite and flint. The sandstone was afterwards found to contain Glauconite, and may be termed Glauconitic Sandstone. Almost every fragment yielded fossils, mostly casts of small shells. At 3 feet the clay became finer and the sandstone fragments more abundant. At 4 feet they were in layers among the clay, gradually thinning out and disappearing, as described by Dr. Ferguson. At 5 feet, on the south side of the shaft, a deposit of fine white sand was found, in which were pebbles of granite, quartzite, and flint. In the other part of the shaft the clay continued, with numerous bits of the grey glauconitic sandstone in a layer, much broken, dipping to the south, which is the direction of the slope of the surface of the ground at Moreseat. The mass of sand increased down to 8 feet, where it ended. At the bottom of the sand there was a block of granite a foot in diameter, and under it a large flint pebble. At 10 feet there was, on one side, a mass of black clay

with a soapy feel, in which sandstone fragments, much worn, were found. This black clay stopped at 11 feet. At 14 feet it began to appear again, and to take the place of the yellowish-brown clay, which ended at 16 feet. The lower part of it contained many stones. From this level the black clay continued all the way down to 30 feet, where it was succeeded by red laminated clay, without stones of any kind. The black clay contained large stones of granite and quartzite and small fragments of the glauconitic sandstone all the way, but the stones grew fewer in number the deeper the shaft was sunk, and the sandstone fragments had almost ceased at 27 feet. The excavation could not be carried farther than 30 feet, because, on reaching the red laminated clay, water began to come in and the funds were exhausted.

The Committee regret that they were unable to ascertain the nature of the solid rock under the shaft. Most likely it would have been found to be granite, the rock seen at the sea-coast from Cruden Bay to Peterhead. The shaft was evidently in glacial drift clay all the way, and therefore the sandstone fragments were not *in sitû*, but had been transported, apparently from the north. By a series of pits a few feet deep made in this direction it might be possible to follow the sandstone farther up the hill, and a shaft sunk at the uppermost place where they could be found might discover the bed from which they came; yet the Committee cannot venture to express a confident opinion that another excavation would be more successful than the last in finding the origin of the Glauconitic Sandstone. Many appearances indicate that the latest changes on the surface of the ground in the district in which Moreseat is situated were caused by local glacial sheets, perhaps not on a great scale, yet capable of moving great quantities of loose and soft matter. The white sand in the shaft seemed to have been moved bodily from a bed seen to the north-west at a higher level. The original seat of the Glauconitic Sandstone may have been to the north of the shaft, a little farther up the hill, and yet the bed may have been entirely removed by ice descending the hill. If, however, the British Association renew the grant, the Committee will be happy to make another attempt to find the origin of the Moreseat fossils.

Mr. Tocher, F.I.C., analyzed the clays found in the shaft, and ascertained that the reddish colour of the one was due to ferric oxide of iron, and the black colour of the other to ferrous oxide.

Mr. Insch collected a large quantity of sandstone fragments containing fossils. These were examined by Mr. A. J. Jukes-Browne, and will ultimately be deposited either in the Aberdeen University Museum or in that at Peterhead.

2. Report on the Fossils by A. J. Jukes-Browne, B.A., F.G.S.

The existence of Cretaceous fossils, embedded in a kind of "Greensand," and found at Moreseat, near Aberdeen, has been known to geologists for nearly fifty years. Mr. W. Ferguson

discussed them in a paper read before the Philosophical Society of Glasgow in 1849, and subsequently communicated to the *Philosophical Magazine*.[1] In this he observes that most of the remains are casts, and he mentions the occurrence of several species of *Ammonites* and *Belemnites*, as also of *Cardium*, *Terebratula*, *Trochus*, *Solarium*, *Cerithium*, and *Spatangus*.

Some of Mr. Ferguson's fossils were examined and named by Mr. J. W. Salter in 1857,[2] who gave a list of fourteen species, two of them being Ammonites doubtfully referred to—*Am. Selliguinus*, Brong., and *Am. Pailletianus*, D'Orb. Four of the others he describes as new species, and from the remaining six he comes to the conclusion that the fauna is of Upper Greensand age.

From 1857 to 1896 no further light was thrown on the subject, but in the latter year some of the fossils collected by Messrs. Mitchell and Insch were submitted to Messrs. Sharman and Newton, who made a careful examination of them, and communicated the results to the GEOLOGICAL MAGAZINE.[3] They compared these fossils with the specimens described by Salter, which are preserved in the Museum of Practical Geology, and found the matrix to be the same. They also state that though slight differences are noticeable in different pieces of the rock, yet all the samples are "so similar that one can scarcely question their having been originally derived from the same bed."

They found, however, that many of the fossils could not be identified with any Upper Greensand species, but were Lower Cretaceous forms, many of them identical with those occurring in the Speeton Clay. They admitted, however, a few species which occur in the Upper Cretaceous series only, and have not been found in any British Lower Cretaceous deposit. Hence they conclude "that the faunas which in the south mark the distinct horizons of Lower Greensand, Gault, and Upper Greensand are here in Aberdeenshire included in one bed of nearly uniform character throughout." This conclusion certainly invested the Moreseat fossils with still greater interest than they possessed before.

A collection of the fossils was sent to me by the Rev. John Milne in September, 1896, but it was impossible for me to examine them in time to report on them before the meeting of the British Association in that year. I have since, however, given them careful attention, and have received much assistance from Messrs. Sharman and Newton, whose previous acquaintance with many of the species has saved me much time and labour.

It is not an easy task to identify these Moreseat fossils, for they are all in the state of casts and impressions. In no case does any actual shell or test remain, but the firmness of the rock has in most cases prevented the enveloping matrix from being pressed down on to the internal cast, so that the external cover generally retains the shape and impression of the original shell, and a mould

[1] Phil. Mag., vol. xxxvii, p. 430 (1850).
[2] Quart. Journ. Geol. Soc., vol. xiii, 1857, p. 83.
[3] GEOL. MAG., Dec. IV, Vol. III, 1896, p. 247.

can, if necessary, be taken from it. The fossils had been carefully collected, and as both casts and covers had been transmitted, it has been possible to determine many of the species.

Before discussing the species, however, the rock itself merits description, for its peculiar characters seem to have escaped previous observers. To the eye it presents itself as a very fine-grained siliceous rock, resembling malmstone, dark grey when damp and freshly broken, drying to a lighter grey. Fractured surfaces often show spots and patches of darker material than the rest of the mass. Under the lens it showed a finely granular matrix, containing many small grains of glauconite and numerous flakes of mica, with small patches of a yellowish-green mineral which is apparently a decomposition product.

The general aspect and light specific gravity of the rock led me to suspect the presence of colloid silica, and accordingly I sent specimens to Mr. W. Hill, F.G.S., for microscopical examination. Mr. Hill cut slices from two of these, and furnishes me with the following account of the structure exhibited by them: — "The material of both slides is alike, and compares most nearly with the micaceous sandstone of Devizes (Upper Greensand). The groundmass consists of amorphous and semi-granular silica, neutral to polarized light, with little or no calcite. There are many sponge spicules, the walls of which have mostly disappeared, but which are outlined in the matrix. The space once occupied by the spicule is often partly filled with globules of colloid silica, like those in malmstone described by Dr. Hinde,[1] and similar globules are dispersed through the mass of rock. There is much quartz sand in small, angular, even-sized grains, but not so much as in Devizes sandstone. Glauconite grains are also abundant, but the quantity varies much in different parts of the rock; the grains seem to be breaking up, and are often seamed with vein-like markings. There are also larger patches of dirty-green material, which has a somewhat indefinite outline, and may be of secondary formation. Small flakes of mica are scattered through the slides, but it is only when these are cut transversely that the mineral can be easily identified."

From the above description it will be seen that the rock may be termed a *gaize*—that is, a fine-grained sandstone, in which colloid silica is an important ingredient; this is not a common rock, and in England it is only known as occurring in the Upper Greensand in association with malmstone. In France a gaize of Lower Gault age, containing *Ammonites mammillatus* and *Am. interruptus*, occurs in the Ardennes (Draize), but I can find no record of the rock occurring in the Lower Cretaceous series either in France or Germany.

The formation of gaize and malmstone probably took place in clear water of a moderate depth; it is not a shallow-water deposit, and yet it was deposited within the range of a current which carried

[1] Phil. Trans. Roy. Soc. 1885, pt. ii, p. 403.

fine sand. The abundance of sponge spicules shows that the conditions were such as to favour the growth of siliceous sponges.

Remarks on some of the Fossils.

The collection sent to me includes some species which have not yet been recorded from the Moreseat rock, and as these are all Lower Cretaceous forms, the Vectian element in the fauna is clearly very strong—so strong indeed that I am led to doubt the existence of some of the Upper Cretaceous species which have been supposed to occur. I shall therefore offer some remarks on certain species, and give a complete revised list of the Moreseat fauna, so far as it is at present known.

Micrabacia coronula, Goldf.—This identification requires confirmation. It depends solely on Salter's authority, for the specimen he saw is not in the Jermyn Street Museum, and no other specimen has been detected in the collections recently made. The species is not known to occur below the Upper Greensand zone of *Pecten asper*, and would be difficult to recognize from a cast only.

Echinoconus castanea, Brong.—This also requires confirmation, for the specimen so named by Mr. Salter has not been found at Jermyn Street, and no other example has been seen. In England its earliest appearance is near the top of the Upper Greensand, but in Switzerland it ranges down to the base of the Gault (see De Loriol in "Echinologie Helvétique"), so that it may in some localities range even lower. No species of *Echinoconus*, however, has yet been recorded from rocks of Lower Cretaceous age.

Discoidea decorata (?), Desor.—This specimen was among those sent by Mr. Milne. It consists of a nearly perfect external mould in two parts. It differs from *D. subucula* in having close-set rows of nearly even-sized tubercles, eight rows on the inter-ambulacral areas, four on each set of plates, and four rows on the ambulacral areas; but the two inner ambulacral rows do not reach either to the apex or to the peristome. The mouth and vent are both rather large. In these respects it agrees with *D. decorata*.

Mr. C. J. A. Meyer having informed me that he possessed specimens of a *Discoidea* from the Vectian of Hythe, the Moreseat specimen was sent to him for comparison. He reports that it agrees with those from Hythe, but he is doubtful whether they are referable to *D. decorata*, Desor, or *D. macropyga*, Ag. Both are Lower Cretaceous species.

Rhynchonella compressa.—The specimen so named by Salter is at Jermyn Street, and has been examined again by Messrs. Sharman and Newton, with the result that they think it is only a compressed variety of *Rh. sulcata*, Park. As specimens of *Rh. sulcata* are not uncommon at Moreseat, and as it is a very variable form, *Rh. compressa* may safely be excluded from the list.

Waldheimia faba, D'Orb. (*non* Sow.).—One specimen apparently referable to this species is among those sent to me. As it is only

a cast and as the shell is smooth, one cannot be quite sure of the species, but the shape is well preserved, and I am indebted to Mr. Meyer for pointing out that it has the squareness towards the front which is characteristic of the species in question. This is well shown in the example figured by Davidson ("Cret. Brach.," vol. iv, pl. vi, figs. 12–14), which came from the Speeton Clay of Knapton in Yorkshire.

Lima semisulcata, Sow.—This species has appeared in previous lists on the authority of Mr. Salter, but the specimen is in the Jermyn Street Museum, and Mr. Newton informs me that it is only an internal cast, and may, with equal probability, be referred to *L. Dupiniana*. As specimens of the latter do occur, and none referable to *L. semisulcata* have since been found, I think this Upper Cretaceous species may be omitted from the list.

Arca securis, D'Orb.—I have ventured to enter the common *Arca* of the Moreseat sandstone under the name of *securis* instead of under *carinata*, because the specimens I have examined seem to me to come nearer to *securis*, and Mr. Meyer, to whom a specimen was sent, is of the same opinion. The two species are so closely allied that some palæontologists regard them as identical; but there are slight differences, and Messrs. Sharman and Newton agree with me in considering the Moreseat specimens to be smaller and shallower in the valve than the ordinary *A. carinata* of the Upper Greensand; and in these respects they resemble *A. securis*. In some of them, moreover, the ribs on the posterior area are like those in D'Orbigny's figure of *securis*; so that, if the forms are separable, I think these should be listed as *securis*.

Leda scapha (?), D'Orb.—I have seen two casts which probably belong to this species, though they equally resemble *L. Mariæ* of the Gault, for, as Mr. Gardner has remarked, there is very little difference between these species.

Pectunculus umbonatus, Sow.—This is another of Mr. Salter's identifications, and unfortunately it also is only an internal cast. There are several species of *Petunculus* to which such a cast might belong, but the probabilities are against its being *P. umbonatus*. As no other specimen has occurred among the fossils recently collected, it will be best to leave it without a specific name for the present.

Turbo Triboleti (?), Pict. and Camp.—There is one specimen, a portion of the external impression of the shell, showing an ornamentation closely resembling that of *Turbo Triboleti*, which is a species from the Upper Gault of Ste. Croix. This specimen was sent to Mr. Meyer, who informs me that he has an imperfect specimen from the Vectian of the Isle of Wight which it equally resembles.

Ammonites flexisulcatus (?), D'Orb.—A small Ammonite was found in breaking up a lump of the material sent to me, and was

forwarded, with other specimens, to Messrs. Sharman and Newton. They reported that it most resembles *A. flexisulcatus*, though the portion preserved is smooth and without sulcations.

Nautilus sp., Sow.—Among the fossils sent to me by Mr. Milne is the cast of a Nautilus, badly preserved, but showing strong transverse rugations or ribs like those of *N. radiatus*, but its condition is such as to prevent any certainty of identification. Mr. A. H. Foord has kindly examined the specimen, but could not venture to name it.

In previous Collections.	In Mr. Milne's Collection.	Moreseat Fossils.	Speeton Clay and Lower Greensand.	Lower Gault.	Upper Gault and Malmstone Group.	Greensand of *Pecten asper* Zone.
		Actinozoa.				
		Coral (like Micrabacia)				
		Echinoderms.				
p.		Ananchytes (? Cardiaster)				
p.	M.	Discoidea decorata, Desor (?)	*			
p.		Echinocyphus difficilis, Ag.				*
p.	M.	Enallaster Scoticus, Salter				
p.		Echinoconus castanea (?)		*	*	*
		Annelida.				
p.		Serpula, sp.				
		Polyzoa.				
p.		Entalophora (?)				
		Brachiopoda.				
p.	M.	Rhynchonella sulcata, Park.	*	*	*	
p.		Terebratula, sp.				
	M.	Terebratella (cast only)				
	M.	Waldheimia faba, D'Orb. (non Sow.)	*			
p.		,, hippopus var. Tilbyensis, Dav.	*			
		Lamellibranchiata.				
	M.	Anatina, sp.				
p.	M.	Arca securis, D'Orb.	*			
p.		,, Raulini (?), D'Orb.	*	?		
p.	M.	Astarte striato-costata, Forbes	*			
p.	M.	Avicula simulata, Baily				
p.	M. ?	Cardium Raulinianum, D'Orb.	*	*		
	M.	Cardium, sp. (cast only)				
p.		Corbula, sp.				
p.	M.	Cyprina Fergusoni, Salter				
p.	M.	Exogyra (small species)				
p.		Gervillia solenoides, Defr.	*	*	*	
p.		,, near to rostrata				
p.		Goniomya, sp.				
p.		Inoceramus, sp.				
	M.	Leda scapha, D'Orb.	*			
p.		Lima Dupiniana, D'Orb.	*			
	M.	,, longa (?), Röm.	*			
p.		,, near to abrupta, D'Orb.				
p.	M.	Limopsis texturata, Salter				
p.	M.	Lucina, sp.				
	M.	Ostrea frons (?), Park. (carinata, Sow.)	*	*	*	*
p.		Panopea, sp.				
p.	M.	Pecten orbicularis, Sow.	*	*	*	*
p.		Pectunculus, sp.				

In previous Collections.	In Mr. Milne's Collection.	Moreseat Fossils.	Speeton Clay and Lower Greensand.	Lower Gault.	Upper Gault and Malmstone Group.	Greensand of *Pecten asper* Zone.
p.	M.	Pinna tetragona, Sow.	*	*	*	
p.	M.	Plicatula placunea, Lam.	*	?		
p.		Spondylus, sp.				
	M.	Tellina, sp.				
	M.	Thetis (?)				
p.		Trigonia Vectiana, Lyc.	*			
	M.	,, sp. nov.				
	M.	Venus Brongniartina (?), Leym.	*			
		Gastropoda.				
p.		Acteon, sp.				
p.	M.	Cerithium aculeatum, Forbes MS.	*			
p.	M.	Dentalium cœlulatum, Baily				
p.		Phasianella (like ervyna, D'Orb.)				
	M.	Solarium. sp.				
p.	M.	Trochus pulcherrimus	*			
p.		,, sp.				
	M.	Turbo Triboleti (?), P. & C.	*		*	
		Cephalopoda.				
	M.	Ammonites flexisulcatus (?), D'Orb.	*			
p.	M.	,, Mortilleti, P. & Lor.	*			
p.	M.	,, Speetonensis (var.)	*			
p.		,, Selliguinus (?), Brong.		*		
p.		Belemnites, sp.				
p.		Crioceras Duvallii, Lév.	*			
	M.	Nautilus, like radiatus, Sow.	?			

It only remains to indicate the conclusion to which the study of the Moreseat fossils has led me.

Of the species enumerated by Mr. Salter in 1857 four have been omitted from the preceding list, being regarded as doubtful identifications which have not been confirmed by subsequent discoveries. Of the three genera of Echinoderms mentioned by him the *Discoidea* was probably the species which resembles *D. decorata*, and the two named respectively *Diadema* and *Ananchytes* may have been Lower Greensand forms for anything that we know to the contrary.

The number of named species available for comparison with other faunas is now 33. Out of this total no fewer than 25 are species of Lower Cretaceous age, and only 7 of these range into the Gault; 5 are species which have not been found elsewhere, 2 are Upper Greensand species, but one of these is a doubtful determination, and 2 are Ammonites, of which the identification is also doubtful. There is therefore an overwhelming proportion of exclusively Lower Cretaceous species, namely 18 to 2, while out of the 6 Cephalopods 5 are exclusively Lower Cretaceous forms, the only one which is not being the very doubtful *Am. Selliguinus*.

The occurrence of one Upper Greensand Echinoderm (*Echinocyphus difficilis*), and the possible occurrence of another ranging

from Lower Gault to Chalk (*Echinoconus castanea?*), is hardly sufficient evidence to warrant the conclusion that a part of the rock-mass was of Upper Greensand age. There is nothing except the *Am. Selliguinus* that is specially characteristic of the Gault, and the question is this: What is the evidential value of the occurrence of *Echinocyphus difficilis*, and possibly also of *Echinoconus castanea* (?)? I think it may be answered in this way: it is more reasonable to suppose that these two species, or forms very closely allied to them, date really from Lower Cretaceous times, than it is to suppose the deposition of exactly the same kind of rock material should have continued at any one place from the time of the Lower Greensand to that of the Upper Greensand. In other words, I believe that the rock-mass from which the Moreseat fossils have been derived was entirely a Lower Cretaceous rock, but high in that series, and corresponding approximately to the Aptien stage of France, and to the Lower Greensand or Vectian of the Isle of Wight.

VI.—On the Continental Elevation of the Glacial Period.

By Prof. J. W. Spencer, M.A., Ph.D., B.Sc., F.G.S.

Contents:

Introduction.—Character of the Submarine Antillean Valleys.—Gradients of Submarine Valleys.—Date of the Continental Elevation.—Migration of Mammals.—Submarine Channels off the Eastern Coast of America.—Submerged Plateau of the North Atlantic.—Continental Elevation a Cause for Glacial Climate.

Introduction.

BEFORE the last meeting of the British Association, held in Liverpool, Professor Edward Hull presented a paper upon "Another Possible Cause of the Glacial Epoch." In that paper, Professor Hull applied the writer's work on the "Reconstruction of the Antillean Continent,"[1] which brought together evidence of great continental elevation. This elevation and its effects upon the ocean-currents, in diverting them from the West Indian regions, with the consequent reduction of their temperature as they reach the northern latitudes in conjunction with the elevation of the land, were thought by Professor Hull to be sufficient causes for the production of the glacial climate over temperate regions in late geological times. The writer has hitherto never applied his observations on high continental elevation to climatic changes; but in this paper he proposes to extend briefly his researches from the Antillean region to the higher latitudes of America and the North Atlantic regions. Something has also been learned of the date of the great elevation; consequently inferences may be drawn as to climatic changes.

Character of the Submarine Antillean Valleys.

The feature of the paper on the "Reconstruction of the Antillean Continents," and subsequent observations of the region, show that

[1] J. W. Spencer, "Reconstruction of the Antillean Continent": Bull. Geol. Soc. Amer., vol. vi, pp. 103-140, 1894.

there are deep valleys, often of great length, extending from the mouths of the existing rivers, and crossing the American coastal plains, over deeply-buried channels. These are plainly recognizable in soundings upon the submarine coastal plateaux, and amongst the banks and islands of the neighbouring West Indian seas, to depths of 12,000 feet or more, before reaching the oceanic floors. The drowned valleys radiate from the continental margins and extend in a direction across that of the coast, and the mountain ranges to the back of it. Their courses do not usually coincide with those of the mountain folds. These submarine valleys are often recognizable for hundreds of miles in descending to the floors of the ocean-basins, as may be seen amongst the Bahamas. Frequently the divides between different systems are themselves submerged, as in the Straits of Florida. The submerged valleys are no broader than those of existing rivers, such as those of the Amazon and the St. Lawrence, nor indeed are they usually as wide. The Colorado cañon, from five to twelve miles across, between walls of 2,000 feet in height, is wider than some of the drowned valleys, which in part are cañon-like. Both the submarine plateaux and the floors of the valleys are like comparatively level plains or base-levels of erosion, which represent pauses when the streams and atmospheric agents could not further deepen their valleys, but only broaden them out into plains, until a subsequent elevation of the region permitted the streams once again to deepen their channels.

Gradients of Submarine Valleys.

The gradients of the submerged valleys (except along the reaches crossing extensive plains, now below sea-level) can only be compared with those of plateau regions, and not with the slopes of such a river as the Mississippi, which flows over great plains at low elevation. The manner in which the valleys descend from one platform to another is illustrated in the plateau region of Mexico and the West. An example of the declivity of such valleys may be seen along the Mexican Railway, back of Vera Cruz, and another above Monterey. The land valleys are made up of a series of steps with greater declivities between them than occur between those submerged. The various platforms represent the rise of the land during the excavation of the valleys. The gradients of the submerged plateaux are frequently as small as, or smaller than, those of such plains as the Mississippi, while the declivities at their margins are less abrupt than those of the land valleys descending from tablelands, as may be seen by comparing them with the Mexican valley sections. The gradient of the Colorado river, in its cañon 3,000 feet deep, is greater than that of the submerged platforms. Besides the greater valleys, descending from the high plateaux, there are many short tributaries, heading in amphitheatres, where the slopes may be from 200 to 600 feet per mile; the whole resembling gigantic "wash-outs." So also similar short drowned valleys occur on the edges of the submarine plateaux. The data concerning these comparative declivities were not obtained when the

original paper upon the submarine river-like valleys was prepared, but they now greatly strengthen the inferences that the drowned plateaux may be used as "yardsticks" for measuring the amount of late continental elevation.

In his paper referred to, Professor Hull endorses the correctness of the interpretation that the submerged valleys were formed by atmospheric agents. Such inferences being correct, the West Indies formed a high continental plateau, while the Gulf of Mexico and the Caribbean Sea were plains or inland lakes draining into the Pacific Ocean across what are now low passes of Mexico and Central America.

Date of the Continental Elevation.

Elsewhere the writer has shown[1] that the old Mio-Pliocene surfaces extended much beyond their present limits, and were subjected to long-continued reduction to base-levels of erosion. Upon the undulations of the country then produced, the Lafayette deposits of the continent form an extensive mantle, which has been provisionally considered as belonging to the late Pliocene epoch. The surfaces are enormously denuded. Following this formation northward, although there are but few exposures of contact, the writer has observed near Somerville, N.J., the Lafayette overlain by a few feet of glacial drift, which has been extensively denuded, as it is locally wanting. Resting upon the boulder drift, and where this has been removed, upon the underlying Lafayette loams and gravels, the Columbia formation may be seen. This feature shows that the epoch of glacial deposits occurred between the Lafayette and Columbia periods. Consequently, the epoch of great elevation, which favoured the excavation of the valleys, coincided with that of the glacial deposits of the early Pleistocene days.

Migration of Mammals.

The Antillean Continent formed a bridge connecting North and South America, over which only a few mammalian remains have been found, as the greater portion of it is now beneath the sea. At Port Kennedy, Pennsylvania, an extensive fauna has been discovered in fissures, and upon it Professor Edward D. Cope was engaged at the time of his recent death, but some results he had made known. Of 38 species of mammals, so far determined, a large percentage are extinct, and among these occur *Equus* and *Megalonyx*. There is also an abundance of remains of an old form of South American bear, which are not known to have crossed the plains of the West. The occurrence of these types at Port Kennedy, Professor Cope regarded as strongly supporting the theory of the Antillean bridge in the early Pleistocene epoch. There is also a newer cave-fauna in Eastern North America, which belonged to a later period, separated from the first by a partial submergence, according to the conclusions of that distinguished author. *Elephas* has recently been found in Guadeloupe.

[1] "Reconstruction of the Antillean Continent," cited before.

Submarine Channels off the Eastern Coast of America.

The submerged valleys, which are best developed among the Bahamas and off the adjacent portions of the continent, provide the key for interpreting the submarine features of other regions. The broad subcoastal plain off the south-eastern States becomes narrowed to a few miles east of Cape Hatteras; but northward it broadens again, and eventually reaches a width of nearly 300 miles south-east of New England, and more than that across the submarine plateau which forms the Newfoundland banks. East of Labrador it has a considerable breadth, but the soundings there are too scanty for its delineation. In drawing the contours at a considerable distance apart, the same forms of indentation are repeated in the borders of the plateau as those observed farther south; but where the contours are drawn close together (even where the soundings are not as numerous as is desirable), the deep valleys are found to be continuations of existing rivers. Thus, Lindenkohl[1] traces the Hudson River channel to a depth of 2,832 feet, and the Great Egg Harbour channel to 2,334 feet, where the plateau is submerged only 600 feet. The Delaware and the Susquehanna valleys are also recognizable on the subcoastal plain to depths of about 3,000 feet.

In 1889, the writer showed how the Laurentian valley was submerged for a distance of 800 miles, beneath the waters of the Gulf of St. Lawrence, with the channel from 1,200 to 1,800 feet below the surface of the sea; but near the edge of the drowned plateau it descends abruptly to a depth of 3,666 feet.[2] The same is true of the valleys crossing the New England, Nova Scotia, and the Newfoundland banks. From the edge of the continental shelf, the Susquehanna valley descends precipitously to a depth of more than 9,000 feet, with its valley recognizable to 12,000 feet. The Delaware descends abruptly to 6,066 feet, and is plainly traceable to 11,256 feet, and to greater depths beyond. The same is true of the Hudson and its tributaries from Connecticut, being recognizable to depths of more than 12,000 feet. From the borders of Massachusetts, Nova Scotia, and the Newfoundland banks the valleys descend precipitously into amphitheatres 6,000 or 7,000 feet below the surface, and continue to depths of 12,000 feet, and in some cases to even 15,000 feet.

While to an unknown extent the drowned plateaux are covered with Tertiary formations, still the submerged valleys must, to a considerable extent, have been excavated out of hard Palæozoic and older strata, thus producing variations in the lengths of the deeper channels, and forming a contrast with some of those of the Antillean region.

From analogy with land valleys, the channels crossing the submarine coastal plains of a few hundred feet, afterwards of perhaps 3,000 feet, represent a long period of elevation. Then followed the

[1] American Journal of Science, vol. xli, p. 490, 1891.

[2] J. W. Spencer, "High Continental Elevation preceding the Pleistocene Period": Bull. Geol. Soc. Amer., vol. i, p. 65, 1889.

great elevation of perhaps two miles or more in height, continuing only long enough to allow the streams to dissect the margins of the tablelands, and form amphitheatres belonging to the new base-level of erosion. While the great depressions shown in the soundings may have in part been occasioned by an exaggerated oceanic subsidence along the line of the continental margin, yet amongst the West Indies it has been found that the actual depression has exceeded two miles. Although the deeper valleys of the north may be less than a hundred miles in length, their slopes are no greater than those of the valleys descending from the Mexican plateaux.

From the generalization of facts just given, the conclusion is, that the high continental elevation of the Antillean region extended northward in Eastern America, of which supporting data have been collected as far as Labrador.

Submerged Plateau of the North Atlantic.

If the analytical methods which have revealed the drowned valleys of the American coast be applied to the well-known North Atlantic plateau, similar valley-like phenomena will be discovered. While there are numerous soundings across the Atlantic, in the region of latitude 52°, the lines of soundings to the north are too far apart to everywhere afford detailed study of the submarine features; except that they show an extensive submerged plateau (from 7,000 to 9,000 feet) rising northward to the Iceland ridge, beyond which it again descends rapidly to depths of 12,000 feet, and west of Spitzbergen, 15,900 feet. The summit of the plateau, between Greenland and Norway, is submerged scarcely more than 1,200 feet. However, across the summit there are deeper channels, from the *cols* of which, valleys trend in opposite directions, like those amongst the West Indies or in the Straits of Florida. These *cols* are now submerged: that between Greenland and Iceland, to 1,974 feet; between Iceland and Faroe, 1,814 feet; between Faroe and Shetland, somewhat more than 3,000 feet; and between Shetland and Norway, about 1,000 feet. The southern margin of this plateau (in the region of latitude 52° N.) is indented by embayments and amphitheatres, similar to those of the border of the American plateau. From the comparatively numerous soundings upon the summit of the divide, and in the adjacent Arctic sea, the valleys from the *cols* just mentioned, and many others, can be traced to abyssmal depths. Thus, that between Greenland and Iceland descends rapidly from a depth of 2,000 feet to 6,642 feet, and may be followed to a depth of 9,000 feet. The valley in the opposite direction from the same *col*, extends northward, and receives the tributary from the Scoresby Sound (which is 1,800 feet deep far within the Greenland mass). In latitude 74°, there is a remarkable amphitheatre of 5,520 feet in depth; and just south-west of Spitzbergen, a similar amphitheatre of 8,100 feet in depth is found where the plateau is submerged only a few hundred feet. Spitzbergen and Norway are connected by a plateau which is generally depressed to less than 1,200 feet. From it valleys descend to the Greenland sea.

The Baltic valley hugs the coast of Norway, and beyond that it extends to the same sea. From the *col* of the channel between Faroe and Shetland, at a depth of somewhat more than 3,000 feet, a great valley extends southward. North-west of Ireland, this valley reaches a depth of 9,980 feet, upon the north-westward side of which the plateau is characterized by shallow banks; and it continues to a depth of 12,000 feet at the margin of the plateau. Tributary amphitheatres to this great valley may be seen westward of Ireland. One of these is 8,160 feet deep, where the platform has been depressed 5,040 feet; and two others have a depth of 10,500 feet, where the plateau is submerged only 4,000 feet. Further southward, extending from the oceanic basin, a large embayment indents and extends far into the platform south-west of Ireland, having still a depth of 10,500 feet, where the shelf is covered by only about 2,500 feet of water. The Bay of Biscay is a remarkable embayment of great depth, with tributary amphitheatres like those just mentioned. The amphitheatres mentioned have no extraordinary widths. Their land equivalents are characterized by inconsiderable streams descending precipitously over steps from plateaux of great altitude.

It is manifest, that Europe and Greenland form one continental mass, while the latter country is separated by a much deeper sea from the American continent. Accordingly, the search for these drowned valleys should be made by means of numerous soundings along lines parallel to the Iceland ridge, rather than off the coast of Ireland. From the fragmentary knowledge already acquired, it would be reasonable to expect the discovery of as complete systems of river-valleys as those found off the American coast and in the Antillean regions; indicating a late continental elevation of 12,000 feet or more.

Continental Elevation a Cause for Glacial Climate.

As has already been stated, the great continental elevation of Eastern America occurred during the early Pleistocene period, and was characterized by a stupendous amount of erosion, with the production of cañons and amphitheatres (at the heads of the valleys). Such an elevation of two miles or more, as measured by the depths of the valleys, must have produced a glacial climate in the more northern regions of America and of the North Atlantic. Thus we find a cause for the Glacial epoch; but many of the phenomena cannot be considered here. Whether the elevations of the North Atlantic and the American regions were absolutely simultaneous, or compensated each other with alternations, like the Antillean and Mexican undulations, is not known. Such alternations, with their diversions of the oceanic and atmospheric currents, together with the more recent partial submergence of the northern lands, would produce variations of the glacial phenomena, and would bring into close proximity those of high elevation and submergence, and of warmer and colder climates.

From as yet unpublished data, it appears that the late Pleistocene

depression of base-level in New England reached 2,700 feet at least. As there was a Mid-Pliocene (our separation of Pliocene and Pleistocene formations being largely arbitrary) elevation of undetermined amount, and as there have been several minor oscillations of level of land and sea, there is great latitude in the application of the phenomena to the Glacial epoch not yet determined—only that great elevation of measurable amount did obtain in Pleistocene days. With alternations of elevation between the North Atlantic and American plateaux, the changes of currents would further modify the climatic conditions of the period, so that this paper only suggests one phase of physical changes—tending to produce the phenomena of the Glacial period.

NOTICES OF MEMOIRS.

I.—The Affinities of *Hesperornis*.[1] By O. C. Marsh.

In the autumn of 1870, I discovered in the Cretaceous of Western Kansas the remains of a very large swimming bird, which in many respects is the most interesting member of the class hitherto found, living or extinct. During the following year, other specimens were obtained in the same region, and one of them, a nearly perfect skeleton, I named *Hesperornis regalis*.[2] In subsequent careful researches, extending over several years, I secured various other specimens in fine preservation, from the same horizon and the same general region, and thus was enabled to make a systematic investigation of the structure and affinities of the remarkable group of birds of which *Hesperornis* is the type. The results of this and other researches were brought together in 1880, in an illustrated monograph.[3]

In the concluding chapter on *Hesperornis*, I discussed the affinities of this genus, based upon a careful study of all the known remains. Especial attention was devoted to the skull and scapular arch, which showed struthious features, and these were duly weighed against the more apparent characters of the hind limbs, that strongly resembled those of modern diving birds, thus suggesting a near relationship to this group, of which *Colymbus* is a type. In summing up the case, I decided in favour of the ostrich features, and recorded this opinion as follows:—

"The struthious characters seen in *Hesperornis* should probably be regarded as evidence of real affinity, and in this case *Hesperornis* would be essentially a carnivorous, swimming ostrich." ("Odontornithes," p. 114.)

This conclusion, a result of nearly ten years' exploration and study, based upon a large number of very perfect specimens and a comparison with many recent and extinct birds, did not meet with

[1] From the American Journal of Science, vol. iii, 1897.

[2] Silliman's Journal, vol. iii, p 56, January; and p. 360, May, 1872.

[3] "Odontornithes: a Monograph on the Extinct Toothed Birds of North America." 4to, 34 plates; Washington, 1880.

general acceptance. Various authors who had not seen the original specimens, or made a special study of any allied forms, seem to have accepted without hesitation the striking adaptive characters of the posterior limbs as the key to real affinities, and likewise put this opinion on record. The compilers of such knowledge followed suit, and before long the Ratite affinities of *Hesperornis* were seldom alluded to in scientific literature.

Several times I was much tempted to set the matter right as far as possible by reminding the critics that they had overlooked important points in the argument, and that new evidence brought to light, although not conclusive, tended to support my original conclusion that *Hesperornis* was essentially a swimming ostrich, while its resemblance to modern diving birds was based upon adaptive characters. On reflection, however, I concluded that such a statement would doubtless lead to useless discussion, especially on the part of those who had no new facts to offer, and, having myself more important work on hand, I remained silent, leaving to future discoveries the final decision of the question at issue.

It is an interesting fact that this decision is now on record. A quarter of a century after the discovery of *Hesperornis*, and a decade and a half after its biography was written in the "Odontornithes," its true affinities, as recorded in that volume, are now confirmed beyond dispute. In the same region where the type-specimen was discovered, a remarkably perfect *Hesperornis*, with feathers in place, has been found, and these feathers correspond with the typical plumage of an ostrich.[1]

II.—On the Relations and Structure of certain Granites and associated Arkoses on Lake Temiscaming, Canada.[2] By A. E. Barlow, M.A., and W. F. Ferrier, B.Sc., Geological Survey of Canada.

THE rocks to which the following facts relate outcrop on both the eastern and western shores of Lake Temiscaming immediately north of the "Old Fort" Narrows on the upper Ottawa river, the deep channel of which forms the boundary-line between the Provinces of Ontario and Quebec.

On the eastern side of the lake the granite forms a strip along the shore half a mile wide, extending from a point three-quarters of a mile north of "The Narrows" on which is situated the now abandoned Fort Temiscaming, a fur-trading post belonging to the Hudson Bay Company, to the steamboat wharf near the village of Baie des Pères. It also constitutes the rocky promontory known as Wine Point to the west of Baie des Pères, extending inland in a north-easterly direction for about one mile and a quarter. On the western side of the lake the first outcrop is noticed about half a mile west of "The Narrows," continuing along the shore for about four miles as far as

[1] Williston, Kansas University Quarterly, vol. v, p. 53, July, 1896.

[2] Abstract read before the British Association, Section C (Geology), Toronto, 1897.

Paradis Point, and varying in breadth from half a mile to one mile. The whole area thus underlain by the granite is approximately about six square miles.

Macroscopically the fresh rock is a rather coarse, though very uniformly even-grained aggregate of felspar, quartz, and a dark-coloured mica, probably biotite. Felspar is by far the most abundant constituent, and the abundance of red oxide of iron disseminated through all the cracks and fissures of this mineral gives to the rock its beautiful deep flesh-red colour. The quartz is, as usual, allotriomorphic, but a decided tendency is noticed to segregate in more or less rounded areas or individuals which, especially on surfaces worn and polished as a result of glacial action, gives to the rock a porphyritic or pseudo-conglomeratic appearance; a fact first made note of by Sir William Logan in 1844 on his manuscript map of this portion of the Ottawa river.

The microscope shows the rock to be composed essentially of orthoclase, microcline, plagioclase (oligoclase?), quartz, and biotite almost completely altered to chlorite. The microcline has evidently been derived from orthoclase as a result of pressure, and all the gradations of this change may be noted, from the "moire structure" characteristic of the imperfectly or only partially developed mineral, to the fine and typical "cross-hatched structure" peculiar to this mineral. The felspar shows only incipient alteration to sericite, and scales and flakes of this mineral are developed especially abundantly in the central portion of the individuals, leaving a comparatively fresh periphery almost altogether free from such decomposition products.

The arkose with which this granite is associated and surrounded is a beautiful pale or sea-green quartzite or grit, passing occasionally into a conglomerate, the pebbles of which are chiefly grey and red quartz with occasional intermixed fragments of a hälleflinta-like rock.

Under the microscope the finer-grained matrix appears to be almost wholly composed of pale yellowish-green sericite in the form of minute scales and flakes, although occasional individuals are macroscopically apparent. Most of this sericite has originated from the decomposition *in sitû* of felspar originally present, and irregular portions or areas of the unaltered felspar may be occasionally detected.

The line of junction between this granite and arkose shows a gradual and distinct passage outward or upward from the granite mass. The series of thin sections examined, as well as the hand-specimens themselves, show every stage in the process, which has been carefully studied.

In the first place, as a result of dynamic action, the orthoclase is converted into microcline with the incipient development of sericite, which gradually increases in those specimens where the greatest perfection of the "cross-hatched" microcline structure is reached. In these the individuals of quartz and felspar have undergone rather extensive fracturing, but with little or no movement apart of the fragments. This breaking up of the original larger individuals is,

as usual, much more apparent in the quartz than in the felspar, and beautiful examples of "strain-shadows" may frequently be seen in those quartz areas which have not yielded altogether to the pressure. A further stage in the process is reached when the sericitization of the felspar has proceeded so far as to permit of the "shoving apart" of the fragments by the various forces which have acted in bringing about the degradation of the whole rock mass. This gradual decomposition of the felspar and movement of the rock constituents can be perfectly traced in the series of thin sections examined until the rock cannot be distinguished from an ordinary arkose, while the arrangement on the large scale, and the more or less parallel alignment of rounded and waterworn quartzose fragments, amply testify to the final assortment and rearrangement of the disintegrated material as a result of ordinary sedimentation.

The relations between this granite and arkose are of rather unusual scientific interest, showing, as they do, the Pre-Huronian existence of a basement or floor upon which these sediments were laid down, and which in this portion at least has escaped the movements to which the Laurentian gneisses have been subjected. The granite is also somewhat different, both in composition and appearance, from the granites and gneisses classified as Laurentian, and which are so frequently referred to as the Fundamental Gneiss or Basement Complex, although during recent years the assumption implied in these terms has been considerably weakened by the fact that the contact between such rocks and the associated clastics is, wherever examined, one of intrusion. On the other hand, the composition of the Huronian strata furnishes indubitable evidence of a pre-existing basement or floor essentially granitic in composition, while the abundance of red granite pebbles and fragments, which are so pre-eminently abundant in the breccia-conglomerate lying at the base of the Huronian system, are very similar in composition and appearance to the granite described above. This granite is, therefore, regarded by the authors as the only instance at present known in which the material composing the Huronian clastics can be clearly and directly traced, both macroscopically and microscopically, to the original source from which it has been derived.

III.—The Fossil Phyllopoda of the Palæozoic Rocks. Thirteenth Report of the Committee, consisting of Professor T. Wiltshire (Chairman), Dr. H. Woodward, and Professor T. Rupert Jones (Secretary). (Drawn up by Professor T. Rupert Jones.)[1]

§ I. 1889–1892. Anomalous Silurian Phyllopods (?) from Germany and America.—In the *Sitz.-Ber. Gesell. naturf. Freunde zu Berlin*, 1890, p. 28, Dr. A. Krause described a small fossil carapace of doubtful alliance, but possibly related to the Phyllopods, from the North-German gravel of Scandinavian *Beyrichia*-limestone (Upper Silurian). In the *Zeitsch. Deutsch. Geol. Gesell.*, vol. xliv, 1892, p. 397, pl. xxii, figs. 19 *a–c*, Dr. A. Krause redescribed and figured this anomalous little fossil.

[1] Read before the British Association, Section C (Geology), Toronto, 1897.

Its lateral moieties are not free, separate valves, but united by an antero-dorsal suture for a third of its length, and by an antero-ventral suture for half of its length, the posterior region remaining open at the edges. It also shows in front a round aperture, with a sulcus formed by the somewhat inverted edges below it. The test is nearly oval and compressed; thickest and subacute in front; bearing a small, low, subcentral swelling. The surface has some reticulate ornament along the margins for the most part, succeeded by linear, radiating, and concentric sculpture towards the more convex area, which is finely punctate. It is 6 mm. long, 4 mm. high, and 1·5 mm. thick.

In S. A. Miller's "North-American Geology and Palæontology," 2nd edition, 1889, p. 549, fig. 1,009, an allied form is described and figured as *Faberia anomala*, n. sp. et gen., from the Hudson-River group, Ohio (Lower Silurian). This has evidently some analogy to the foregoing Upper Silurian form. It has a compressed, ovoidal, smooth shell, consisting of two moieties, partially sutured above and below, and is rather smaller than the German specimen.

§ II. 1885–1894. Cambrian Phyllopoda (?).—Dr. G. F. Matthew, of St. John, New Brunswick, has discovered several very small organisms in the Cambrian rocks of North-Eastern America, some of which he regards, with doubt, as having been carapace-valves of Phyllopodous Crustaceans. He has described and figured them in the Transactions of the Royal Society of Canada.

To this group of small subtriangular valve-like bodies, obliquely semicircular or semi-elliptical, with straight hinge-line and more or less definite umbo, belong (1) *Lepiditta alata*, M., Trans. Roy. Soc. Canada, vol. iii, 1885, sect. 4, p. 61, pl. vi, figs. 16, 16*a*; (2) *L. curta*, M., p. 62, pl. vi, fig. 17; (3) *Lepidilla*[1] *anomala*, M., p. 62, pl. vi, figs. 18, 18*a*, *b*, *c*; (4) *Lepiditta sigillata*, M., xi, 1894, sect. 4, p. 99, pl. xvii, fig. 1; (5) *L. auriculata*, M., p. 99, pl. xvii, figs. 2, 2*a*, *b*. Some of these were referred to by us in the Sixth Report (for 1888), p. 174.

§ III. 1889. *Rhachura venosa*, Scudder, 1878, Proc. Boston Soc. Nat. Hist., vol. xix, p. 296, pl. ix, figs. 3, 3*a* (referred to in our Report for 1883, p. 216). Dr. A. S. Packard, having received from M. Gurley some imperfect specimens found in the Middle Coal-measures, Danville, Illinois, describes them as being parts of a carapace, probably a little over three inches long, and three caudal spines, also rather obscure (Proc. Boston Soc. Nat. Hist., vol. xxiv, 1889, pp. 212, 213).

§ IV. 1893. *Rhinocaris columbina.*—Mr. J. M. Clarke has contributed a paper "On the Structure of the Carapace in the Devonian Crustacean *Rhinocaris*, and the relation of the Genus to *Mesothyra* and the Phyllocarida," with illustrative cuts, published in the *American Naturalist*, Sept. 1, 1893, pp. 793–801. The carapace-valves of *Rhinocaris columbina* (J. M. C., "Palæont. New York,"

[1] Dr. G. F. Matthew, in a letter of November 5, 1897, expresses a "wish to withdraw *Lepidilla*, as not being a Crustacean; more perfect specimens seem to show a fan-like structure of internal tubes."

vol. vii, 1888, pp. lviii and 195–7) are described from better specimens, which show it to be a bivalved (not univalved) form, and as having a narrow, median plate, of which there is evidence in *Mesothyra*, making a double dorsal suture. There is also a long, narrow, leaf-like rostrum inserted between the valves in front. The relationship of this form with *Mesothyra* and *Tropidocaris* is dwelt upon. The author thinks that *Dithyrocaris* and *Emmelezoe* have some affinity with it. *Rhinocaris* and *Mesothyra* are regarded as typical members of the family Rhinocaridæ. We may mention that Dr. Matthew regards his *Ceratiocaris pusilla* from the Silurian of New Brunswick (see Trans. Roy. Soc. Canada, vol. vi, 1888, sect. 4, p. 56, pl. iv, fig. 2; and our Seventh Report, for 1889, p. 64) as *Rhinocaris*.

§ V. 1895. *Emmelezoe Lindstroemi*.—Since our Twelfth Report, presented to the British Association at Ipswich in 1895, the Swedish Phyllocarids mentioned in that Report as having been found by Dr. Gustav Lindström in the Upper Silurian beds at Lau, Gothland, have been duly described and figured in the Geological Magazine, Decade IV, Vol. II, No. 378, December, 1895, pp. 540, 541, Pl. XV, Figs. 2*a*–2*d*, as *Emmelezoe Lindstroemi*, J. and W. The fish-remains (*Cyathaspis*) and other fossils associated with it are mentioned in detail by G. Lindström in the *Bihang till K. Svensk. Vet.-Akad. Handl.*, vol. xxi, part 4, No. 3, 1895, pp. 11, 12.

Mr. J. M. Clarke has suggested at p. 801 of his memoir, mentioned in § IV, that the oculate genus *Emmelezoe* may have some relationship to the group to which *Rhinocaris* belongs.

§ VI. 1895. *Pinnocaris Lapworthi*.—This genus, represented by its only known species, *P. Lapworthi*, has been carefully examined by Woodward and Jones, and several specimens described, selected from a large number in Mrs. Robert Gray's collection at Edinburgh. This memoir appeared in the Geological Magazine, Decade IV, Vol. II, 1895, pp. 542–5, Pl. XV, Figs. 5–10. Excepting one specimen from the Upper Silurian of Kendal, Westmoreland, all the known specimens are from the Lower Silurian of Girvan, Ayrshire, where Mrs. Gray has made a large collection.

The peculiar "corded" dorsal margin of the valves may have reference to some longitudinal, narrow, intermediate ligament or plate as in *Rhinocaris* and *Mesothyra*.

§ VII. 1895. A new species of *Ceratiocaris* (*C. reticosa*, J. and W.), preserved in the Museum of the Geological Survey, was described in the Geological Magazine, Decade IV, Vol. II, 1895, pp. 539, 540, Pl. XV, Figs. 1*a*, 1*b*. It is from the Silurian beds of Ludlow, Shropshire, and is allied to *C. cassioides*, from that locality. Traces of a peculiar reticulate sculpture constitute its distinguishing feature.

§ VIII. 1895. *Lingulocaris*.—In the same number (378) of the Geological Magazine, 1895, at pp. 541, 542, a specimen *Lingulocaris lingulæcomes*, Salter, belonging to the Rev. G. C. H. Pollen, S.J., F.G.S., was figured and described. It came from Capel Arthog, North Wales, probably from the Ffestiniog or middle division of the

Lingula-flags. Hence we may add "*Lingulocaris*" to "*Hymenocaris*" for that formation at p. 425 of our Twelfth Report (fifth line from the bottom).

§ IX. 1896. Devonian species of *Ceratiocaris* (?). — In the "Monograph of the Devonian Fauna of the South of England," Palæont. Soc., vol. iii, part 1, 1896, the Rev. G. F. Whidborne describes and figures three obscure casts of *Ceratiocaris*, one *C.* (?) *subquadrata*, sp. nov., p. 7, pl. i, fig. 5, from East Anstey; another, *Ceratiocaris* (?) sp., p. 8, pl. i, fig. 6, from Sloly; and the third, somewhat indistinct specimen, namely *Ceratiocaris* (?) sp., p. 8, pl. ii, fig. 12, from Croyde.

§ X. 1896. *Entomocaris* and *Ceratiocaris*. — A collection of *Ceratiocaris*-like Crustaceans from the Lower Helderberg Formation (Upper Silurian), near Waubeka, Wisconsin, has afforded Mr. R. P. Whitfield, of the American Natural History Museum, New York, the opportunity of determining two new species of *Ceratiocaris*, and a new genus (*Entomocaris*), allied to *Ceratiocaris*, but differing from it by the carapace-valves being "strongly curved in front and behind on the dorsal margin," and by the posterior margin not being truncate, as in *Ceratiocaris*, but obtusely rounded. *Entomocaris Telleri*, Whitfield (p. 300), is figured in pl. xii, of full size, but slightly distorted by pressure. Including the four exposed body-segments and the trifid appendage, it is about 21 centimetres (about 8 inches) long; and the valves are about 13½ centimetres long by about 6½ high. Some indications of the swimming-feet attached to the body are visible where one valve has been partially broken away from the internal cast. Some mandibles, supposed to belong to this species, are shown in pl. xiv, figs. 1, 2; and the caudal appendages in fig. 9.

Ceratiocaris Monroei, Whitfield (p. 301, pl. xiii, figs. 1–5, and pl. xiv, figs. 3–8), is carefully described from one nearly perfect and an imperfect specimen, together with body-segments, caudal appendages, and some mandibles. The carapace-valves seem to have been about 7½ centimetres long and 4 high.

Ceratiocaris poduriformis, Whitfield (p. 302, pl. xiv, fig. 10), is represented by a small specimen of abdominal segments and caudal spines.

§ XI. 1896. *Echinocaris Whidbornei*, J. and W., noticed in our Seventh Report (for 1889), p. 63, has been redescribed and refigured by the Rev. G. F. Whidborne in the "Monogr. Devonian Fauna, S. England," Pal. Soc., vol. iii, part 1, 1896, p. 6, pl. i, fig. 3.

Within the last few months Ananda K. Coomáry-Swámy, Esq., of Warplesdon, has fortunately obtained a very interesting specimen of this *Echinocaris* from the Sloly mudstone, showing on the two counterparts of the little split slab, two individuals, each having the same characters as the specimen first described in the Geological Magazine, Decade III, Vol. VI, 1889, p. 385, Pl. XI, Fig. 1. Though rather narrowed by oblique pressure, the valves are equal in breadth to those of the first specimen. An additional feature of interest is seen in some body-segments, five in one individual and

three in the other. In each case, though the series of segments is not complete either at beginning or end, they are characteristically like those of *Echinocaris*, the distal edges bearing tubercles, the equivalents of spinules.

§ XII. 1896. *Caryocaris.*—In the Journal of Geology, Chicago, vol. iv, 1896, p. 85, Dr. R. R. Gurley has described *Caryocaris* as the "lateral appendages" of the "polypary" of a Graptolite! *Caryocaris* was referred to by us in the First and Seventh Reports (for 1883 and 1891), and was described in detail and figured in the "Monogr. Brit. Palæoz. Phyllocarida," Pal. Soc. 1892, p. 89 et seq., pl. xiv, figs. 11–18.

§ XIII. 1897. A new locality in Nova Scotia has been determined by Sir William Dawson for *Estheria Dawsoni*, namely, East Branch, East River, Pictou County, Lower Carboniferous. Several casts and impressions of small valves, not more than two millimetres long, occur on the bed-planes of a dark-red Lower Carboniferous shale. Former occurrences of this species were noticed in our Report (Eleventh) for 1894.

REVIEWS.

PETROLOGY FOR STUDENTS: AN INTRODUCTION TO THE STUDY OF ROCKS UNDER THE MICROSCOPE. By ALFRED HARKER, M.A., F.G.S. Second edition, revised. 334 pp., 75 figs. (Cambridge: Messrs. C. J. Clay & Sons, 1897. Price 7*s.* 6*d.*)

THE appearance within two years of a second edition of so excellent a textbook as Harker's "Petrology for Students" is not a subject for surprise. In this revised edition the author states that he has endeavoured to profit by the criticisms of reviewers and private friends. The slight alteration, however, which the book has undergone shows how little cause for adverse criticism there was in the first edition. In general plan and scope the book remains precisely the same. Only about thirty pages have been added, and these are mainly due to the introduction of descriptions of American examples among the igneous rocks, one result of which is, that the reader makes the acquaintance of a number of those new names (Absarokite, Banakite, Carmeloite, Shonkinite, etc.) to the invention of which American geologists have of late been perhaps a little too prone.

The method of classification of the igneous rocks remains practically the same, but Brögger's name "hypabyssal" is substituted for "intrusive." As the author remarks, "petrology has not yet arrived at any philosophical classification," and certainly the attempt to pigeonhole the igneous rocks, both basic and acid, into the three groups, plutonic, hypabyssal, and volcanic, involves inconsistencies which are evident in the text. Thus three chapters intervene between the descriptions of such similar rocks as the pitchstones of Arran and the "pitchstones" (or, as the author prefers to call them, the Permian rhyolites) of Meissen; while the

treatment of the Derbyshire "toadstones" rather leaves the impression that they would have been described in connection with the Shropshire "diabases" but for the fact that "Mr. Arnold Bemrose regards them as contemporaneous lavas." That there should be any difficulty in naming a rock before its mode of occurrence, either as an intrusive mass or as a lava-flow, has been determined, may present no terrors to the field-geologist; but to the Museum-Curator it is hardly less appalling than the idea that before giving a rock a name it is necessary to determine its geological age. The author, it is true, is faithful to the British School in rejecting any distinction between rocks drawn from geological age; but the simplification in classification which should follow the removal of this incubus is partly discounted in this, as in many other English textbooks, by the fact that the hypabyssal groups are to a large extent recruited from rocks which are so mildly intrusive as to be included by Continental writers in their palæovolcanic groups (Ergussgesteine).

The book has been brought up to date by references to recent work, and still remains, what it was recognized to be on its first appearance, one of the most trustworthy guides for the student who wishes to take up the microscopic study of rocks. G. T. P.

REPORTS AND PROCEEDINGS.

Geological Society of London.

I.—November 17, 1897.—Dr. Henry Hicks, F.R.S., President, in the Chair. The following communications were read:—

1. "The Geology of Rotuma." By J. Stanley Gardiner, Esq., B.A. (Communicated by J. E. Marr, Esq., M.A., F.R.S.)

The author describes the relationship of the island of Rotuma (situated in lat. 12° 30′ S., long. 177° 1′ E.) to the adjoining isles. It is almost separated into two parts, which are united by a narrow neck of sand. The interior is composed of volcanoes, which have emitted lavas and fragmental rocks. Around the volcanic rocks are stratified deposits composed of sea-sand with volcanic fragments. These are partly denuded, and are mantled round by coral-reef and beach sand-flats. A remarkable cavern in the lava of Sol Mapii, with lava-stalactites, is described; there is a similar cavern in Au Huf Huf.

An account of the prevalent meteorological conditions is also given.

In an Appendix by Mr. H. Woods, M.A., some of the rocks are described. They consist of olivine-dolerites and basalts and associated fragmental rocks.

2. "A Geological Survey of the Witwatersrand and other Districts in the Southern Transvaal." By Frederick H. Hatch, Ph.D., F.G.S.

After giving an account of the physical characters of the area, the author proceeds to describe the various rocks referred to

(1) The Karoo System,
(2) The Cape System,
(3) The Primary or Archæan System.

The Archæan rocks protrude in a few places through the sedimentary beds, which form the greater part of the area, and consist of an igneous complex of rocks of varied composition.

The Cape System is capable of division into five distinct series:—

Upper Beds.	Magaliesberg and Gatsrand series; alternating quartzites, shales, and lava-flows. 16,000 to 20,000 feet.
	Dolomite and cherts, thickly bedded. 6,000 to 8,000 feet.
	Black Reef; a bed of quartzite and conglomerate, 20 to 50 feet, and Klipriversberg amygdaloid; a basic volcanic rock, 5,000 to 6,000 feet.
Lower Beds.	Witwatersrand Beds; sandstones and conglomerate (in part auriferous). 11,000 to 15,000 feet.
	Hospital Hill series; quartzites and ferruginous shales. 8,000 to 10,000 feet.

A full description of each of the series, and the associated volcanic and igneous rocks, is given in the paper.

The Karoo formation is represented by the Coal-measures of Vereeniging and the district south of Heidelberg, and by the measures of other coal-areas. They have furnished plants which Mr. Seward refers to in a note as being of Permo-Carboniferous age.

The age of the Cape System is doubtful. The Upper beds rest unconformably on the Lower ones, and if the latter be of Devonian age, as has been inferred, the former may represent the Lower Carboniferous rocks.

In conclusion the author makes some observations upon the geotectonic relations of the area.

3. "Observations on the Genus *Aclisina*, De Koninck, with Descriptions of British Species, and of some other Carboniferous Gastropoda." By Miss J. Donald, of Carlisle. (Communicated by J. G. Goodchild, Esq., F.G.S.)

The author makes some preliminary observations on the genus *Aclisina*, and considers it advisable to regard *A. pulchra* as the type of the genus, while the so-called *A. striatula* must be placed among the *Murchisoniæ*, and *A. nana* is placed in a new genus. The author gives a diagnosis of *Aclisina*, De Kon., belonging to the family Turritellidæ, and describes the British species, twelve of which are new, including two new forms placed in a subgenus.

Of the family Murchisonidæ, and in the section *Aclisoides* of the genus *Murchisonia*, the form of *A. striatula*, De Kon., and a variety are described; and a diagnosis of the new genus, in which *A. nana* of De Koninck is placed, is given, followed by a description of the species.

II.—December 1, 1897.—Dr. Henry Hicks, F.R.S., President, in the Chair. The following communications were read:—

1. "A Revindication of the Llanberis Unconformity." By the Rev. J. F. Blake, M.A., F.G.S.

In a paper published in the Quarterly Journal of the Society for 1893, the author of the present paper maintained that certain conglomerates and associated rocks occurring for some distance north-east and south-west of Llanberis, which had hitherto been

considered to lie below the workable slates of the Cambrian rocks of that area, were in reality unconformable deposits of later date than those slates. In 1894 (Quart. Journ. Geol. Soc., vol. L, p. 578), Professor Bonney and Miss C. A. Raisin maintained that in no case which they had examined could any valid evidence be found in favour of the alleged unconformity, and that in one (on the north-east side of Llyn Padarn) which they supposed to afford the most satisfactory proof of it, the facts were wholly opposed to the notion.

The present paper is a reply to these authors, in which their objections, founded on general considerations, on field observations, and on microscopic examination of rock-specimens, are discussed, and the author gives the results of further observations on the rocks of the district. The Moel Tryfaen sections and those on each side of Llyn Padarn in the Llanberis district are considered, and he maintains that the post-Llanberis (using this term in the sense of being after the deposition of the main workable slates) age of the conglomerates which are under discussion is established; though the more he considers the correlation of these conglomerates with the Bronllwyd Grits the less he likes it, and as far as the stratigraphy is concerned, they may be much newer—their age is at present an open question; but of their unconformable position he has no doubt.

2. "The Geology of Lambay Island, Co. Dublin." By Messrs. C. I. Gardiner, M.A., F.G.S., and S. H. Reynolds, M.A., F.G.S.

The authors, who have previously described the neighbouring district of Portraine (Quart. Journ. Geol. Soc., Dec. 1897), undertook an examination of this island, with the intention of comparing the rocks with those of Portraine, and of investigating the nature of the rock familiar to geologists under the name of "Lambay porphyry." The sedimentary rocks are similar to some of those of Portraine, and are of Middle or Upper Bala age. Associated with them are pyroclastic rocks and andesitic lava-flows, some of the lavas having flowed beneath the sea. The sediments and volcanic rocks were exposed to denudation, and a conglomerate composed of their fragments was accumulated round the volcano. The "Lambay porphyry," which has been determined as a diabase-porphyry by Dr. von Lasaulx, is partly intrusive in the other rocks, but has in places come to the surface as a lava-flow.

Petrographical descriptions of the various rocks are given by the authors.

MISCELLANEOUS.

New Geological Survey Maps. — Since our notice in the Geological Magazine for 1897, p. 192, several other of the Sheets of the General Map of England and Wales (scale one-inch to four miles) have been issued, *printed in colours* and priced 2*s.* 6*d.* each. These include Sheets 2, Northumberland, etc.; 3, Index of Colours; 4, Isle of Man; 7, North-West Wales; 10, Parts of South Wales and North Devon; and 13, Cornwall and the Scilly Isles with part of Devon.